THE SHOCK AND VIBRATION DIGEST

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THE SHOCK AND VIBRATION DIGEST

The **Shock and Vibration Digest** is a monthly publication of the Shock and Vibration Information Center. The goal of the Digest is to provide efficient transfer of sound, shock, and vibration technology among researchers and practicing engineers. Subjective and objective analyses of the literature are provided along with news and editorial material. News items and articles to be considered for publication should be submitted to:

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SVIC NOTES

The Changing Trends in Shock and Vibration Meetings

During the past 20 years both the content and the nature of meetings on shock and vibration have changed noticeably. These changes are reflected in our Shock and Vibration Symposia and in other meetings on this topic.

One of the changes is in the orientation of the papers. A greater proportion of papers presented at the more recent meetings are case history or applications oriented, and I believe this reflects a feeling that many current shock and vibration problems can still be solved by using existing techniques. Budget limitations may also be a reason why fewer technique-oriented papers are presented. Less research of any kind is being performed, and relatively few technology development programs are being funded.

Many new developments, although they are useful, seem to be evolutionary rather than revolutionary. Unfortunately some feel a methods-oriented paper should only be presented if it represents a quantum jump in the technology. Could this attitude be another explanation for the reduced number of technique-oriented papers presented at today's meetings? But even when substantially new methods are developed, the ones who should write about them cannot do it because they do not have the time or the money.

The subjects that are discussed, or the session titles have significantly changed as well. These subject matter changes reflect the changing interests of the shock and vibration community. Subjects are discussed at meetings either because there are new developments or because they are controversial. But a subject may be actively discussed at meetings for several years, and then it might not be actively discussed again for many years. This often happens because significant changes might have occurred during the intervening years to make it necessary to discuss that particular subject again. Pyrotechnic shock is a good example. This subject was actively discussed during the early to mid 1960's; it was actively discussed again at a recent meeting this year; it will be emphasized at the 56th Shock and Vibration Symposium.

The "Short Discussion Topics" type of session is another change in meeting content that is often overlooked. These sessions are organized to deal with descriptions of "hints or kinks" or progress reports on on-going efforts; these presentations do no warrant writing a complete technical paper; so, ordinarily, nothing is published. These sessions are interesting because they provide insight into current work, and many useful "hints and kinks" are often disclosed in these sessions. But, because they are not published these "hints and kinks" are lost, except to those who attend these sessions. Perhaps some provision should be made for publishing these types of presentations.

The nature and the conduct of meetings on shock and vibration have also changed substantially during the past 20 years. Briefly, the changes concern the type of audio-visual equipment used in the meetings, the number of meetings on shock and vibration, and the growing degree of international participation.

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EDITORS RATTLE SPACE

ABSTRACT CATEGORIES

The Abstracts from the Current Literature section of the DIGEST provides a monthly listing of journal articles, reports, and Ph.D. dissertations on shock and vibration technology. This listing of published material provides the reader with an objective view of the literature. In order to make maximum use of the literature and to effect an efficient transfer of information to the practicing engineer and/or scientist, some form of literature characterization must be used. Currently, twelve fundamental categories are used to separate the literature for the monthly review of the reader.

Mechanical Systems	Electric Components
Structural Systems	Dynamic Environment
Vehicle Systems	Mechanical Properties
Biological Systems	Experimentation
Mechanical Components	Analysis and Design
Structural Components	General Topics

These categories are further broken down into subgroups to allow easy access to discrete areas without burden on the reader. In recent issues of the DIGEST we have had a fairly even distribution of articles in most of these categories. This leads one to assume that the present categorization provides a reasonable density of articles in the categories and subcategories. If you the reader have comments on these categories or suggestions on refinement, I would like to hear from you.

R.L.E.

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IMPACTOR INTERACTION WITH CONCRETE STRUCTURES —
LOCAL EFFECTS

H. Adeli* and R.L. Sierakowski**

Abstract. This paper focuses on the local effect of solid impactors acting on concrete structures. Available formulas for predicting the penetration depth, scabbing thickness, and perforation thickness of solid impactors acting on concrete structures are reviewed and compared.

The general effects of impactors impinging on concrete structures can be classified as local or global response mechanisms. Local effects include such phenomena as penetration, scabbing, perforation, spalling, and richochet. Global effects can be considered related to flexural and shear behavior of a target. If the kinetic energy of an impactor missile is considerably smaller than the strain energy capacity of the structures or if a structure is sufficiently rigid, local effects can probably be considered the governing factor in structural response. This paper focuses on the local effects of solid impactors acting on concrete structures.

The problem of impact in relation to concrete structures is extremely complicated. A thorough theoretical analysis of the problem has yet to be developed. However, for design of concrete structures against impact, simple reliable equations are urgently needed. At present only empirical and semi-empirical equations seem to have been developed for design purposes. In this paper, available formulas for predicting penetration depth, scabbing thickness, and perforation thickness of solid impactors acting on concrete structures are reviewed and compared.

DEFINITION AND DELINEATION
OF PHYSICAL PHENOMENA

Penetration is defined by the so-called wetted area of an impactor as it relates to the target or barrier; the impactor does not exit through the back face of the target (Figure 1). Penetration can be accompanied by back face scabbing of the concrete; however, the depth of scabbing is generally less than the thickness of the concrete cover -- the layer of concrete between the surface and first layer of reinforcement. Penetration depth is fundamentally independent of target thickness given a target of sufficient thickness.

Scabbing is the ejection of concrete pieces from the back face of a target (Figure 2). The thickness of ejected pieces is generally at least equal to the thickness of the concrete cover. Scabbing thickness for design purposes represents the minimum barrier thickness required to prevent scabbing. Scabbing generally leaves a crater on the back face of a target and is accompanied by penetration.

Perforation is the through-the-thickness entrance and exit of an impactor through a target (Figure 3). Perforation thickness in design is the barrier thickness required to prevent perforation. At this thickness, the impactor passes through the barrier and exits with a zero residual velocity.

Spalling is the ejection of concrete, generally from the front face (impact face) of a target or barrier. Spalling sometimes is associated with rear face fracture of concrete targets and barriers.

Ricochet is the rebound of an impactor interacting with a target at a nonzero incidence angle. The incidence angle is defined with respect to the normal impact plane, which is measured with respect to the impact surface.

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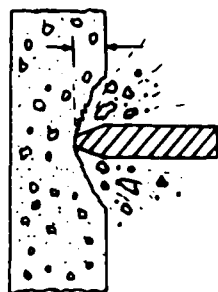
PENETRATION DEPTH
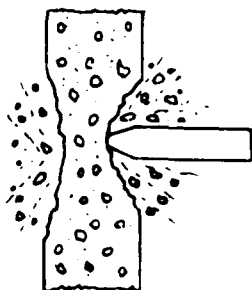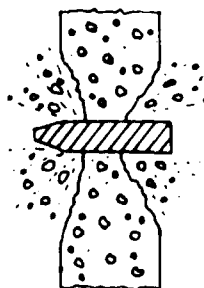
Figure 1. Penetration

Figure 2. Scabbing

Figure 3. Perforation

A summary of available penetration equations along with their limitations are presented in Table 1. Included are the Modified Petry [1, 2]; Army Corps of Engineers, ACE [3]; Modified National Defense Research Committee, NDRC [4, 5]; Ammann and Whitney [6]; Kar [7]; Haldar and Miller [8]; Hughes [9]; and Adeli et al [10]. Certain of the penetration depth formulas [8-10] contain dimensionless parameters; others contain dimensional parameters. A list of nomenclature and appropriate units for the variables used in the dimensional equations are given in the Appendix.

The Petry formula, originally developed in 1910, represents one of the oldest recognized penetration formulas. It can be used to calculate penetration depth in terms of velocity of the impactor V, weight of impactor per unit of impacted area A_p, and type of concrete as represented by coefficient K_p. This coefficient was originally given values of 0.00284 for specially reinforced concrete, 0.00426 for normal reinforced concrete, and 0.00799 for massive concrete, independent of concrete strength. Amirikian [2] improved this equation by introducing a curve that expresses K_p as a function of concrete strength. This curve, however, is applicable for a particular case of reinforced concrete. The revised equation has become known in the literature as the Modified Petry penetration equation.

The ACE [3] penetration equation was developed in 1946 by curve fitting experimental data. For a number of years the National Defense Research Council (NDRC) penetration formula [4], developed and based on a large number of tests made during World War II, remained relatively unknown due to information restrictions. In recent years, however, it has become more widely used than the ACE [3] and other formulas. It was apparently the first penetration equation based upon theoretical modeling considerations; the principal premise is that the impact force increases linearly up to a constant terminal value. Experimental results, however, indicate that this assumption is not valid. The NDRC penetration formula was modified in 1966 to include a penetrability factor K as a direct

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Table 1. Penetration Formulas

	Formula	Theoretical basis	Limitations of applicability
Modified Petry (1910)	I. $x_p = 12 K_p A_p \log(1 + V^2/215000)$ $K_p = 0.0042b$ II. $x_p = 12 K_p A_p \log(1 + V^2/215000)$ K_p is given as a function of concrete compressive strength by a curve.	Empirical	
ACE (1946)	$$\frac{x_p}{D} = \frac{282 \, W}{2785 \, f_c^{\frac{1}{2}} \, D}\left[\frac{V}{1000}\right]^{1.5} + 0.5$$	Statistical fitting of experimental data	
Modified NDRC (1946)	$$\frac{x_p}{D} = \left[\frac{4 K K_1 W}{D}\left(\frac{V}{10000}\right)^{1.8}\right]^{\frac{1}{2}} \qquad \frac{x_p}{D} \le 2$$ $$\frac{x_p}{D} = 1 + \frac{K K_1 W}{D}\left(\frac{V}{10000}\right)^{1.8} \qquad \frac{x_p}{D} > 2$$ K = 0.72 for flat nosed missile. = 0.84 for blunt nosed missile. = 1.00 for average bullet nose (spherical end) = 1.14 for very sharp nose. $K_1 = 180 / \sqrt{f_c}$	Penetration theory and experimental considerations	$3 \le \dfrac{d}{D} \le 18$ $V \ge 500$ ft/sec.
Ammann & Whitney	$$\frac{x_p}{D} = \frac{282 \, K \, W}{D^{2B} \, f_c^{\frac{1}{2}}}\left[\frac{V}{1000}\right]^{1.8}$$		$V \ge 1000$ ft/sec.

Table 1 (continued)

	Formula	Theoretical basis	Limitations of applicability
Kar (1978)	$\frac{x_p}{D} = t + \frac{4 K K_1 W}{D} \left[\frac{E}{E_m}\right]^{125} \left[\frac{V}{1000D}\right]^{18}$ $\frac{x_p}{D} = 1 + \frac{K K_1 W}{D} \left[\frac{E}{E_m}\right]^{125} \left[\frac{V}{1000D}\right]^{18}$ $\frac{x_p}{D} \leq 2$ $\frac{x_p}{D} > 2$ $K = 0.72$ for flat nosed missile. $K = 0.72 + 0.25 (n - .25)^{\frac{1}{2}} \leq 1.17$ for special nose. $n =$ the ratio of the radius of the nose to the diameter of the missile.	Regression analysis	
Haldar & Miller (1982)	$\frac{x_p}{D} = -.02725 + .22024 I$ $0.3 \leq I \leq 2.5$ (a) $\frac{x_p}{D} = -.592 + .446 I$ $2.5 \leq I \leq 3.0$ (b) $\frac{x_p}{D} = .53886 + .06892 I$ $3.0 \leq I \leq 21.$ (c) $I = k W V^2 / g t_c^2 D^3$	Regression analysis	$89 \leq V \leq 1023$ ft/sec. $0.7 \leq d/D \leq 18.$ $D \cdot 12$ $0.24 \leq W \leq 756$ lb $0.3 \leq I \leq 21.$ $X/D \cdot 2$

Hughes (1984)	$\frac{x_p}{D} = 0.19 K' I' / S$
	
	$I' = W V^2 / g f_t D^3$
	$K' = 1.0$ for flat nosed missile.
	     1.12 for blunt nosed missile.
	     1.26 for average bullet nose (spherical end)
	     1.39 for very sharp nose.
		Physical model of the impact process and regression analysis	Targets with light reinforcement
			$1 < 3500$ $(1 < 252)$
			$89 \leq V \leq 1023$ ft/sec.
			$0.7 \leq d/D \leq 18.$ $0 \leq 12$
			$0.24 \leq W \leq 756$ lb.

Adeli et al (1985)	$\frac{x_p}{D} = -.0426 + .1698 I - .0045 I^2$ $\frac{x_p}{D} \leq 2$ $\frac{x_p}{D} = .012 + .196 I - .008 I^2 + .0001 I^3$ $\frac{x_p}{D} \leq 2$	Quadratic and cubic regression analysis	same as Haldar's

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function of the compressive strength of the concrete [5].

Among the older penetration formulas, the NDRC formula has been widely used and favored in the literature [11-13]. Sliter [13] has recently compared the NDRC formula with recent tests and found that, for impact velocities greater than 500 ft/sec, the NDRC formula gives the penetration depth within an error range of 25%, which represents the range of experimental scatter. For smaller velocities, however, he found that penetration depths calculated from the NDRC equation are as much as eight times greater than observed ones.

Kar [7] modified the NDRC equation by including a ratio of the modulus of elasticity of the impactor material to that of mild steel. He pointed out, however, that for most practical cases the ratio is approximately equal to one.

Haldar and Miller [8] determined penetration depth in terms of a dimensionless impact factor I with three linear equations (Table 1). Equations (a) and (c) are based upon a linear regression analysis. The range of applicability of equation (a) was initially selected to be from I = 0.3 to I = 3.0. There seems to be no strong argument, however, for the choice of an impact factor of 3 as a separating point between the two sets of experimental data. The arbitrary choice of 3.0 was troublesome, and they found a discontinuity, or jump, between the two regression lines at the point I = 3.0. In other words, for I = 3.0, equation (a) has a value of X_p/D = 0.63347; however, equation (c) is X_p/D = 0.74562, which is about 18 percent larger than the first value. Considering the relatively few data points used, there appears to be no physical reason for the existence of such a discontinuity. To overcome the difficulty, they drew a straight line between the point I = 3 and X_p/D = 0.74562 of equation (c) and an arbitrarily chosen point I = 2.5 and X_p/D = 0.52335 of equation (a). This line is represented by equation (b) in Table 2. This assumption is very conservative.

Haldar and Hamieh [14] in a recent paper extended the range of the linear penetration equations. They suggested three linear equations for use in the ranges 0.3 < I < 4.0, 4.0 < I < 21.0, and 21.0 < I < 455. However, they did not elaborate the rationale of their separation of ranges within the extended base.

Hughes [9] has also developed impact formulas; they assume the impact force-penetration depth relationship shown in Figure 4. He neglected the linear elastic portion of the curve, however, and assumed a parabola for the nonlinear portion. On the basis of this impact model and using dimensional analysis, he obtained the simple impact formulas given in Tables 1 through 3. He did not evaluate these equations using direct experimental results but used instead data points from the NDRC and ACE formulas.

Based upon quadratic and cubic regression analyses of existing U.S. and European data that have been summarized [13], two formulas have been derived for predicting penetration depth [10]. These new penetration equations are compared statistically with the NDRC penetration formula and two other recent penetration formulas -- the Haldar and Miller formula [8] proposed in 1982 and the Hughes formula [9] proposed in 1984 -- in Figure 5 and Table 4. In general, the variance and coefficient of variation of the new equations are smaller than those values of other formulas (Table 4). Furthermore, the new formulas are advantageous over the NDRC formula because the latter is a dimensional equation. When compared with the Haldar and Miller formula [8] the new equations give the penetration depth continuously in terms of the impact factor using only one equation.

SCABBING THICKNESS

The available scabbing equations are summarized in Table 2 and represent the Modified Petry [1, 2], ACE [3], NDRC [4, 5], Ballistic Research Laboratory (BRL) [15], Bechtel Corporation [16, 17], Stone and Webster [18], Kar [7], Chang [19], and Hughes [9] formulas. The Modified Petry, ACE, NDRC, BRL, and Hughes scabbing equations express scabbing thickness directly in terms of penetration depth.

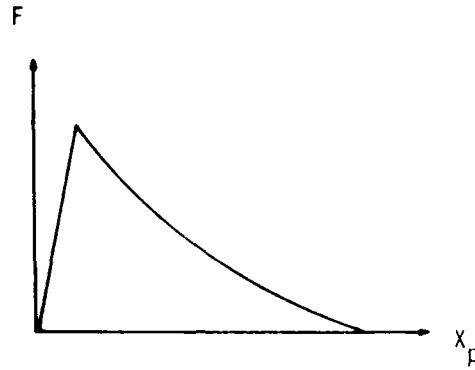In 1976 Kennedy [11] compared scabbing equations developed before that time with

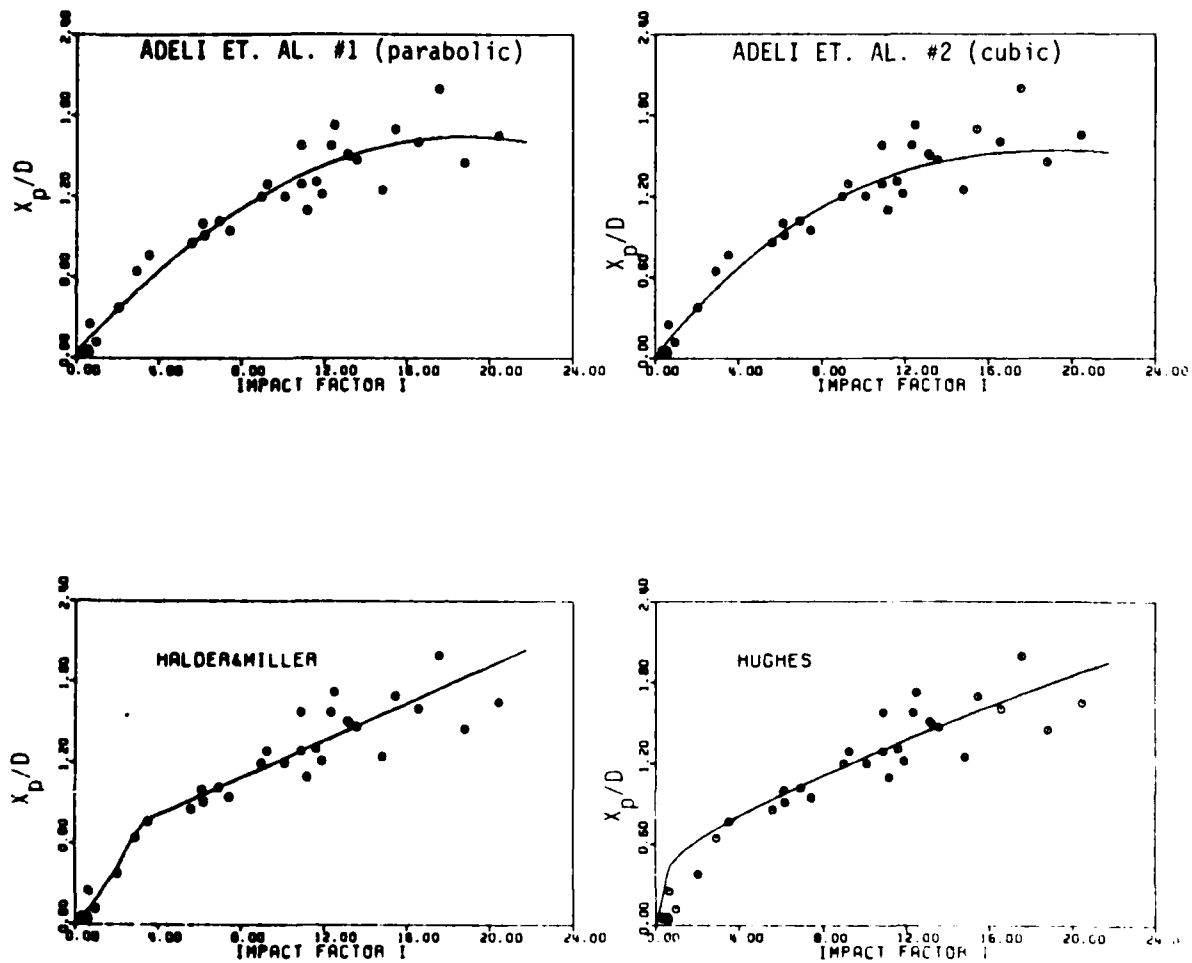**Figure 4. Impact-Force -- Penetration Depth Relationship Used by Hughes [9]**

Figure 5. Comparison of Penetration Formulas

Table 2. Scabbing Formulas

	Formula	Theoretical basis	Limitations of applicability
Modified Petry (1910)	$d_s = 2.2 \, X_p$	Empirical	
ACE (1946)	$\dfrac{d_s}{D} = 2.12 + 1.36 \left[\dfrac{X_p}{D}\right] \qquad 0.65 \leqslant \dfrac{X_p}{D} \leqslant 11.75$	Statistical fitting of experimental data	
Modified NDRC (1946) (1966)	$\dfrac{d_s}{D} = 2.12 + 1.36 \left[\dfrac{X_p}{D}\right] \qquad 0.65 \leqslant \dfrac{X_p}{D} \leqslant 11.75$ $\dfrac{d_s}{D} = 7.91 \left[\dfrac{X_p}{D}\right] - 5.06 \left[\dfrac{X_p}{D}\right]^2, \qquad \dfrac{X_p}{D} \leqslant 0.65$	Penetration theory and experimental considerations	$3 \leqslant \dfrac{d}{D} \leqslant 18$ $v > 500$ ft/sec.
Ballistic Research Laboratory	$d_s = 2 \, d_p$		
Bechtel Corporation	$d_s = \dfrac{15.5 \; W^{0.4} \, V^{0.5}}{f_c^{0.5} \, D}$		

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Table 2 (continued)

	Formula	Theoretical basis	Limitations of applicability
Stone & Webster	$d_s = [\dfrac{W V^2}{c}]^{\frac{1}{3}}$		$300 \leq f'_c \leq 4500$ psi. $1.5 \leq \dfrac{d}{0} \leq 3.0$
Kar (1978)	$b[\dfrac{d_s - a}{D}] = 2.12 + 1.36\,\dfrac{x_p}{D} \quad 0.65 \leq \dfrac{x_p}{0} \leq 11.75$ $b[\dfrac{d_s - a}{D}] = 7.91\,\dfrac{x_p}{D} - 5.06\,[\dfrac{x_p}{D}]^2, \quad \dfrac{x_p}{D} \leq 0.65$ b = coefficient of spalling, a = half of aggregate size	Regression analysis	
Chang (198i)	$d_s = 1.84\,[\dfrac{200}{V}]^{\frac{1}{5}}\,\dfrac{(M\,V^2)^{.4}}{0.7\,f'_c}$	Bayesian analysis and some principles of mechanics	$55 \leq V \leq 1023$ ft/sec. $0.24 \leq W \leq 756$ lb. $2 \leq d \leq 24$ in. $0.79 \leq 0 \leq 24$ in. $3300 \leq f'_c \leq 6600$ psi.
Hughes (1984)	$\dfrac{d}{0} = 5.D\,\dfrac{x_p}{D} \qquad \dfrac{x_p}{D} < 0.7$ $\dfrac{d_s}{D} = 1.74\,\dfrac{x_p}{D} + 2.3 \qquad \dfrac{x_p}{0} \geq 0.7$	Physical model of the impact process and regression analysis	Targets with light reinforcement $1 \leq 35D0 \quad (1 \leq 252)$ $89 \leq V \leq 1023$ ft/sec. $0.7 \leq \dfrac{d}{0} \leq 18, \quad D \leq 12$ $0.21 \leq W \leq 756$ lb.

available experimental data. He found that NDRC scabbing equation agreed with test results generally within ± 20 percent; these results are better than those provided using the other scabbing formulas.

The empirical scabbing equations of Kar [7] include the effects of aggregate size. However, his definition of aggregate size is unclear, and he does not describe the data base used. Data presented in his paper are for aggregate size of the order of only 1.5 in.

Sliter [13] compared NDRC, Bechtel, and Stone and Webster scabbing formulas with recent test results. He found that, except for relatively large-diameter nondeformable cylindrical impactors, all equations estimate the scabbing thickness equally well. He noted, however, that further experiments are needed for large-diameter missiles before the scabbing equations can be used with confidence.

Chang [19] has developed semi-analytical equations for scabbing thickness based upon simplifying assumptions and Bayesian statistics. He considered a circular region around an impact area to estimate the strain energy capacity corresponding to scabbing thickness. As pointed out by Haldar [20], this is in contrast to the experimental observation that cracks develop in an impacted region in all directions. He also derived his scabbing equations without taking into account the effect of missile penetration into a target.

The Petry, ACE, NDRC, BRL, Bechtel Corporation, Chang, and Hughes scabbing formulas have recently been compared [10] with data compiled by Sliter [13]. The following conclusions were made:

> The Modified Petry and BRL formulas have the worst fit with experimentally obtained scabbing thickness and underestimate scabbing thickness in many cases.

> The Hughes scabbing formula is the most conservative equation in predicting scabbing thickness and overestimates scabbing thickness, sometimes by a factor of three.

The ACE, NDRC, Bechtel, and Chang formulas in general predict scabbing thickness safely with a few exceptions. The NDRC and ACE equations give more conservative results than the other two. In terms of closeness of fit, the Bechtel formula appears somewhat better than the others.

PERFORATION DEPTH

The available perforation equations are summarized in Table 3 and are represented by the Modified Petry [1, 2], ACE [3], NDRC [4, 5], BRL [15], CEA-DEF (Commissariat a l'Energie Atomique - Electricite de France) [21], Kar [7], Degen [22], Chang [19], and Hughes [9] formulas. The Modified Petry, ACE, NDRC, Degen, and Hughes perforation equations appear to give perforation thickness directly in terms of penetration depth.

The first NDRC perforation equation in Table 3 is due to Chelapati and Kennedy [23]. In 1976, Kennedy [11] compared the NDRC perforation equation with the Modified Petry, ACE, and BRL formulas and found better agreement with test data for the NDRC equation than other predictors. Sliter [13] in 1980 compared the NDRC and the CEA-DEF perforation formulas with recent test results and found that the latter estimates perforation thickness much more closely than the former.

The Modified Petry, ACE, NDRC, BRL, CEA-DEF, Degen, Chang, and Hughes perforation formulas were recently compared [10] with data compiled by Sliter [13]. The following conclusions were made:

> The Modified Petry and BRL formulas have the worst fit with the experimentally obtained data and underestimate perforation thickness in many cases.

> The Hughes perforation formula in general overestimates perforation thickness more than the other equations.

> The CEA-DEF, Degen, and Chang formulas have the best fit for perforation thickness; they are followed by the NDRC formula.

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Table 3. Perforation Formulas

	Formula	Theoretical basis	Limitations of applicability
Modified Petry (1910)	$d_p = ? \, x_p$	Empirical	
ACF (1946)	$\dfrac{x_p}{D} = 1.24 \dfrac{x_b}{D} + 1.32 \qquad 1.35 < \dfrac{x_p}{D} \leq 13.5$	Statistical fitting of experimental data	
Modified NDRC (1946) (1946)	$\dfrac{x_p}{D} = 3.19 \dfrac{x}{D} - .718 \left[\dfrac{x}{D}\right]^2 \qquad \dfrac{x_p}{D} \leq 1.35$ $\dfrac{x_p}{D} = 1.24 \dfrac{x_p}{D} + 1.32 \qquad 1.35 \geq \dfrac{x_p}{D} \leq 13.5$	Penetration theory and experimental considerations	$3 \leq \dfrac{d}{D} \leq 18$ $V \geq 500 \quad$ ft/sec
Ballistic Research Laboratory	$\dfrac{x_p}{D} = 7.8 \dfrac{W}{D} \left[\dfrac{V}{1000}\right]^{1.33} \qquad$ for $\; f'_c = 3000$ psi $\dfrac{x_p}{D} = \dfrac{427}{D^2 f'^{\frac{1}{2}}_c} W \left[\dfrac{V}{1000}\right]^{1.33}$		
CEA-EDF (1977)	$d_p = 0.765 \, [f'_c]^{-.375} \left[\dfrac{W}{D}\right]^{\frac{1}{2}} V^{.75}$	Least squares	Reinforcing steel $9.34 - 18.7$ p/ft! $4300 \leq f'_c \leq 7300$ psi. $82 \leq V \leq 1476$ ft/sec. $0.345 \leq \dfrac{d}{D} \leq 4.17$

Table 3 (continued)

	Formula	Theoretical basis	Limitations of applicability
Kar (1978)	$$\frac{d_p - a}{D} = 3.19 \frac{x_p}{D} - .718 (\frac{x_p}{D})^2 \qquad \frac{x_p}{D} \le 1.35$$ $$\frac{d_p - a}{D} = 1.74 \frac{x_p}{D} + 1.32 \qquad 1.35 \le \frac{x_p}{D} \le 13.5$$ a = half of aggregate size	Regression analysis	Reinforcing steel 9.97 - 21.8 p/ft.
Degen (1980)	$$\frac{x_p}{D} = 2.2 (\frac{x_p}{D}) - 0.3 ((\frac{x_p}{D})^2 \qquad \frac{x_p}{D} \le 1.52$$ $$\frac{d_p}{D} = 1.29 (\frac{x_p}{D}) + 0.69 \qquad 2.65 \le \frac{d}{D} \le 18$$	Statistical analysis	$82 < v < 1023$ ft/sec. $33 < W < 756$ lb. $4116 < f'_c < 6245$ psi. $6 < d < 24$ in. $4 < D < 12$ in. $0.5 < d/D < 2.7$
Chang (1981)	$$d_p = 200 (\frac{M V}{V})^{\cdot} [\frac{M V}{D f_c}]^{\cdot}$$	Bayesian analysis and some principles of mechanics	$55 < v < 1023$ ft/sec. $0.24 < W < 756$ lb. $2 < d < 24$ in. $0.79 < D < 24$ in. $3300 < f'_c < 6600$ psi.
Hughes (1984)	$$\frac{d_p}{D} = 3.6 \frac{x_p}{D} \qquad \frac{d}{D} \le 3.5$$ $$\frac{d_p}{D} = 1.58 \frac{x_p}{D} + 1.4 \qquad \frac{d}{D} > 3.5$$	Physical model of the impact process and regression analysis	Targets with light reinforcement $1 < 3500 \quad (1 < 252)$ $89 < v < 1023$ ft/sec. $0.7 < d/D < 18, \; D < 12$ $0.24 < W < 756$ lb.

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Table 4. Comparison of Penetration Equations

	NDRC	Halder & Miller	Hughes	Adeli et al #1	Adeli et al #2
Variance	0.03607	0.02515	0.04242	0.02280	0.02315
Coefficient of Variation	0.18035	0.15061	0.19560	0.14339	0.14449

FUTURE RESEARCH

The effect of reinforcement on damage prediction equations (penetration depth, scabbing thickness, and perforation thickness) should be investigated. Surprisingly, researchers report that the effect of reinforcement is negligible. However, very low percentage of steel (0.3 - 1.5 percent) has usually been used in experiments. Actual reinforced concrete structures usually have reinforcement of the order of 1.5 - 3 percent. Two-way reinforcement behaves as a mesh and can substantially enhance impact resistance. Therefore, further experiments are needed with slabs or other types of structural elements with a high degree of reinforcement.

Little is known about the influence of aggregate size and texture on local impact effects. Experiments performed in Great Britain [25] in which the ratio of impactor diameter to maximum aggregate size varied from 0.5 to 50 indicated a weak dependence of penetration depth on aggregate size. This aspect of the impact problem, however, needs further investigation. Aggregate interlocking behavior and bond slip characteristics should be explored to improve the impact resistance of concrete structures.

Constitutive laws for the high strain rate regime and a proper description of material failure are urgently needed. Failure models for multiaxial short time loadings are practically nonexistent. Such models should inevitably be evolved based upon the physical arguments of micromechanics for the various classes of materials used [26].

Available penetration depth, scabbing thickness, and perforation thickness formulas are basically only for normal impact. This is due to the fact that practically all experiments now performed are for concrete targets subjected to normal impact. Research is needed to develop formulas for oblique incidence impacts.

Properly reinforced concrete has substantial ductility and is deformable. Neglecting the deformability of reinforced concrete results in gross overestimation of local effects. The effect of deformability of reinforced concrete structures should be included in damage prediction formulas.

Local and global effects have traditionally been treated independently [27]. A unified treatment of local effects and dynamic structural response would be more appropriate. For such a unified treatment, impact force-time history curves consistent with barrier penetration, scabbing, and perforation must be developed. Sensitivity of structural response to shape, maximum impact force, and duration of impact should be investigated.

The problem-dependence of local impact effects needs to be studied. A majority of experimental results reported in the literature have been performed on concrete walls or slabs. Different results should be expected for such structures as beams and shells.

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APPENDIX — NOTATIONS

a - Half the aggregate size in concrete (in.)

A_p - Weight of impactor per unit project area (lb/ft^2)

d - Thickness of the slab or target (in.)

d_p - Perforation thickness (in.)

d_s - Scabbing thickness (in.)

D - Diameter of the impactor (cylinder) (in.)

E - Modulus of elasticity of impactor material

E_m - Modulus of elasticity of mild steel

f_c - Ultimate concrete compressive strength (psi)

f_t - Tensile strength of concrete (psi)

I - Impact factor WV^2/gD^3f_c

K - Nose shape factor

K_1 - Concrete penetrability

M - Mass of the impactor

n - Ratio of the radius of the nose to the diameter of the impactor

S - Strain-rate factor

V - Impact velocity (ft/s)

W - Weight of the impactor (lb)

X_p - Penetration depth (in.)

LITERATURE REVIEW: survey and analysis of the Shock and Vibration literature

The monthly Literature Review, a subjective critique and summary of the literature, consists of two to four reviews each month, 3,000 to 4,000 words in length. The purpose of this section is to present a "digest" of literature over a period of three years. Planned by the Technical Editor, this section provides the DIGEST reader with up-to-date insights into current technology in more than 150 topic areas. Review articles include technical information from articles, reports, and unpublished proceedings. Each article also contains a minor tutorial of the technical area under discussion, a survey and evaluation of the new literature, and recommendations. Review articles are written by experts in the shock and vibration field.

RECENT RESEARCH IN NONLINEAR ANALYSIS OF BEAMS

M. Sathyamoorthy*

Abstract. This literature survey deals with the static and dynamic nonlinear analysis of beams. Also included are papers about arches, cables, frames, strings, and trusses. Papers reviewed are limited to those published between 1982 and 1984. Geometric and material type nonlinearities are included. Analytical, experimental, and numerical methods are reviewed.

Nonlinear methods of analysis are becoming popular for finding solutions to beam problems. Various types of nonlinearities are usually included in the analysis of nonlinear problems. Geometric nonlinearities arise as a result of large deformations in beams; such nonlinearities are accounted for by considering nonlinear strain-displacement relations. Geometric nonlinearities also arise due to a nonlinear curvature-displacement relationship. Combinations of the two types of nonlinearities also occur.

One type of nonlinearity that is attributed to material behavior is called material or physical nonlinearity. Nonlinear stress-strain relationships give rise to this type of nonlinearity. A combination of geometric and physical nonlinearities is also possible. Governing equations corresponding to each nonlinearity can be derived following a procedure outlined in previous reviews [1, 2].

This literature survey deals with the static and dynamic nonlinear analyses of beams, rods, and columns. Papers dealing with arches, cables, frames, strings, and trusses are included, as are nonlinear effects due to large deformations and stress-strain behavior. Nonlinear methods of analysis including analytical, experimental, and numerical methods are also reviewed. Papers published since 1892 are surveyed; most of the papers are in English.

ARCHES, CABLES, FRAMES, STRINGS, AND TRUSSES

Literature on nonlinear static and dynamic analyses of arches, cables, frames, strings, and trusses published since 1982 is summarized in this section. A geometrically nonlinear analysis of circular and arbitrary arches has been carried out using the finite element method [3]. Postbuckling behavior of plane arches, rings, and frames has been investigated [4]. Dynamic problems of arches including the effects of geometric nonlinearities have been reported [5, 6], as has nonlinear stability of tapered prebuckled arches [7]. Static nonlinear analysis of cable type structures has been studied [8, 9]. In one case only geometric nonlinearity was considered [8]; both geometric and material nonlinearities were included in the other [9]. Dynamic problems of cables have been treated [10-12]. Luongo, Rega, and Vestroni [10] considered the planar nonlinear free vibration behavior of elastic cables; large amplitude free vibrations of a suspended cable have also been considered [11]. Fried [12] used finite element analysis procedures to study the static and dynamic behaviors of extensible cables during deformation.

In the area of frames, almost all investigations since 1982 have been concerned with static nonlinear problems. The influence of discretization density has been examined [13]. Nonlinear analyses of unbraced frames, large deflections of portal frames, large deflection and stability of rigid frames, nonlinear behavior of nonintegral in-filled frames, optimization of frame type structures using nonlinear analysis procedures, large displacement in-plane analysis of elasto-plastic frames, application of the finite element analysis procedure to the nonlinear analysis of elastic-plastic frames, and postbuckling behavior of frames have been reported [14-24, 98].

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Static nonlinear problems concerning elastic strings have been solved [25, 26]. Nonlinear free vibration of a damped elastic string has been considered [27], as has a nonlinear generation method for finding missing modes of a vibrating string [28]. Planar response and stability of strings under narrow-band random excitation has been studied [29].

Recent developments in the nonlinear static and dynamic analyses of trusses have been reported [30-38]. Large displacement analyses of elastic and elastic-plastic trusses are available [30-32]; geometrically nonlinear dynamic analysis methods have been used to solve problems of trusses and truss type structures [33-36]. Theoretical and experimental results concerning trusses are available [37, 38].

BEAMS, RODS, AND COLUMNS

Recent investigations dealing with nonlinear static and dynamic behaviors of beams, rods, and columns have been reported [39-119]. Geometrically nonlinear static problems have been treated [39-72]. A variational method for finite deformation of prismatic beams is available [41, 42]. Pleus and Sayir [44] presented a second order nonlinear theory for large deflections of slender beams; a similar higher order theory applicable to beams has also been derived from three-dimensional elasticity [46]. Curved beams have been treated [49, 50], and a finite strip method has been used [56] in the nonlinear analysis of thin-walled structures. Effects of thermal stresses and high temperatures [55, 61] and various boundary conditions, orthotropy, and transverse shear [70] have been considered.

Nonlinear beam problems with material nonlinearity have been studied [73-80]. Large deflections of nonlinearly elastic beams with various boundary conditions and loading have been considered [74-77]. The material nonlinearity in these cases is represented by a Ludwick type nonlinear stress-strain relationship. Papirno [73] conducted an experimental investigation to check the validity of the Ramberg-Osgood type nonlinear stress-strain relationship to various materials. He found that the Ramberg-Osgood analytic approximation is

an excellent fit to experimental stress-strain data from the proportional limit to 0.2 percent offset yield stress.

Nonlinear dynamic cases of beams in which geometric nonlinearities are considered have been treated [81-102]. Both free and forced vibrations were studied. Transient response of nonlinear beam vibration problems subjected to pulse loading have been considered using a numerical approach [85]. Vibration response of geometrically nonlinear beams subjected to pulse and impact loadings have been investigated using a finite difference method [92]. Gutierrez and Laura [97] studied the effect of concentrated mass on the large amplitude free flexural vibration of beams and plates; Adami [101] presented theoretical and experimental results for the nonlinear response of buckled beams under random excitation. Nonlinear vibrations of rotating shafts [81-83], vibrations of rotating blades [84], nonlinear studies of rotating cantilever beams [99], and nonlinear vibrations of homogeneous viscous beams [98] have been reported.

Postbuckling analyses of elastic and elasto-plastic beams and columns have been published [41, 103-115, 127, 140]. In most of the investigations only geometric nonlinearities are included. Monasa and Lewis [106] considered material nonlinearity in an analysis of the stability behavior of uniformly loaded flexible bars of elasto-plastic material. The finite element method was used in an investigation of thermal post-buckling behavior of tapered columns [108, 109]. The problem of nonlinear bending and collapse of long, thin, open section beams has been solved using microcomputers for a closed, convergent sequence of algebraic and integral equations that are tractable [112]. Anifantis and Dimarogonas [114-115] investigated the postbuckling behavior of cracked columns. Dynamic stability of columns has been considered [116-119, 139]. The effects of transverse shear deformation and rotatory inertia were included in a study of the dynamic stability of bars [116]; bucked beams have also been studied [117]. Braced columns and columns subjected to axial excitation have also been included [118-119].

During the period 1982-1984, advances in the computational methods of nonlinear analysis were made concerning beams and beam-type structures. Use of the finite element method for large deflection, large amplitude vibration, and postbuckling behaviors of beams has been illustrated [40, 70, 108, 109, 117, 121-140]. General purpose nonlinear finite element programs have been developed [121, 126]. Both geometric and material type nonlinearities were considered in nonlinear formulations of problems. Nonlinear vibration problems have been treated [129-138]. Sarma, Prathap, and Varadan [133, 134] studied the applicability of the Ritz finite element method to the solution of nonlinear structural problems with application to beams. The formulation and the solution of the problem of finite elastic-viscoplastic transient deformation of thin beams has been treated [40].

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BOOK REVIEWS

DIGITAL FILTERS

R.W. Hamming
Prentice-Hall Inc., Englewood Cliffs, NJ
1983, 257 pages, $28.95

As stated by the author, "This text includes an accurate (but not rigorous) introduction to the necessary mathematics . . . I have become increasingly convinced of the need for an elementary treatment of the subject of digital filters." Digital filtering involves differentiation, integration, smoothing, and removal of noise from a signal.

The book consists of 14 chapters and 256 pages. Chapter 1 introduces digital filters and explains their use. Chapter 2 considers the frequency approach, including aliasing, invariance under translation, and a definition of an eigenfunction and its use in equally spaced sampling.

Chapter 3 uses the frequency approach in a number of classical applications. The least squares fitting of polynomials, including quadratics and quartics, is described and extended to a modified least squares approach. A method for compensating some faults of the least square methods is suggested. Differences and derivatives, a procedure for supplying missing values by a method of interpolation, an explanation of filter operation, an attempt to smoothing non-recursive filters, and numerical integration applied in recursive filter design are also discussed.

The next chapter discusses Fourier series for a continuous case in terms of orthogonality, odd and even functions expressed by Fourier series, the use of Fourier series in least squares, convergence of a point of continuity and discontinuity, and the relationship of complex Fourier series and phase form. Chapter 5 focuses on windows and presents a good explanation of the Gibbs phenomenon. The author shows how the convolution theorem can generate new Fourier series.

Chapter 6 considers non-recursive filters, including the design of a low pass filter, a differentiation filter, sharpening of a filter, and band pass differentiators. The next chapter is concerned with smooth non-recursive filters. Dr. Hamming discusses the objection to ripples with a transfer function; he shows how a smooth transfer function can be obtained. He describes the filter, design of a smooth filter, and its extension to a smooth band pass filter.

Chapter 8 contains a mathematical explanation of the Fourier integral and the sampling theorem. Included are a derivation of the Fourier integral, an introduction of some transform pairs, and application of the convolution theorem to the Fourier integral. The effect of a finite sample size, the application of Fourier integral to window design, and the uncertainty principle conclude the chapter.

The next chapter describes the shape of the window and its use in truncating the Fourier series. Professor Kaiser suggests that the weights of Fourier coefficients of the rectangular window be supplanted by his function, which contains a factorial representation. It resembles the Hamming window at the ends of the nonzero terms but has a finite value at the middle. The author uses the same procedure to design a non-recursive filter as was used with the Hamming window. Chapter 10 describes finite Fourier series, the relationship between discrete and continuous expansions, and the fast Fourier transform (FFT). The reviewer believes that the discussion of the FFT is too short.

Chapter 11 reviews the spectrum, aliasing effects, and computation of a spectrum from an FFT. The next step is removal of the mean from the data. Dr. Hamming explains that removal of the mean affects

the appearance of the spectrum; resulting data should be carefully scrutinized. A too brief discussion of the phase spectrum concludes the chapter.

Chapter 12 considers recursive filters, which have more memory than non-recursive filters. A recursive filter is a formula for integration that must remember all values back to and including the value at the lower limit of integration. Linear differential and difference equations are then reviewed. Difference equations lead to the Z transform, which is used in the design of the recursive filter. The chapter concludes with an interesting discussion of the Butterworth filter, which is a recursive filter.

The 13th chapter focuses on Chelychev approximation and Chelychev filters. The approximation is probably the most popular for measuring how close a designed filter is to an original transfer function. In a Chelychev fit the sum of the squares of the error is larger than the corresponding least squares fit; conversely, the least squares fit has a larger maximum error than does the Chelychev fit. Consequently, in filter design the Chelychev fit is frequently preferred. The author introduces Chelychev polynomials and the Chelychev criterion, which he uses to derive Chelychev filters, types 1 and 2. An example of the design of an integrator is given. The closing chapter is a short discussion of different types of filters.

This interesting book is kept at an elementary level. The reviewer believes that some computer programs should have been included. A table of nomenclature would help the reader. However, the book is readable and could be used as a text for a beginner interested in filter design.

H. Saunders
1 Arcadian Drive
Scotia, NY 12302

This book is part of an annual review series begun in 1969. It reports the latest information on acoustical holography and imaging and is the proceedings of the Twelfth International Symposium on Acoustical Imaging held during July, 1982, in London, England. The symposium emphasized the study of acoustical visualization and its applications to medical diagnostics and welds and flaws in industrial products and underground structures. A total of 66 papers are included.

Several of the papers on acoustic microscopes concentrate on applications. These include material structure examinations, wear and fracture assessment in silicon nitrides, the structures of semiconductor chips and films, and human tissue characterization. Three papers cover photoacoustic effects; for example, Rayleigh wave imaging and imaging using water jet coupling.

Most of the nine papers grouped under signal processing address computer reconstruction and the range of signal processing techniques available to enhance imaging. Topics include self-focusing algorithms, pulse echo techniques, and optical techniques. Six papers on transducers cover optically-scanned acoustic imaging transducers and the use of axicons; i.e., devices for imaging and amplitude shading. Four papers on multi-element arrays address behavior and characterization of ultrasonic transducers.

Six papers on scattering and propagation emphasize nonhomogeneous, attenuating, and multi-layered media. The 15 papers on applications to medicine cover topics in tissue characterization, doppler imaging, and the use of tomography as a diagnostic technique. Ten papers on imaging systems cover holographic aperture analytical expansions, imaging with arrays, holographic scans, and underwater applications.

A list of attendees includes participants from the United States, Canada, and several European countries and the Far East. This book will be of value to those engaged in the field of acoustic holography and will be a handy reference.

V.R. Miller
5331 Pathview Drive
Huber Heights, OH 45424

UNDERWATER ACOUSTIC SYSTEM ANALYSIS

This text is part of a Prentice Hall series on signal processing. It presents the fundamentals of underwater acoustics, signal generation, and signal processing used by the analyst to study and optimize the performance of underwater acoustic systems.

Chapter one contains a historical review of fundamental discoveries and accomplishments, many of which are from diverse fields and seemingly unrelated technical areas. The following four chapters cover material on the generation and propagation of acoustic waves in the ocean, including effects at surface and bottom boundaries. Acoustic transducers and their operation are also discussed. Chapters six through nine can be considered a review of Fourier methods, correlation functions, and random processes.

Types and properties of ambient noise, including sources and directional characteristics in the ocean, are covered in Chapter 10, as is the effect of the spatial correlation function in calculations. The subject of acoustic beam forming and its use as a filtering operation to improve signal detection in the presence of ambient noise is covered in Chapter 11. The next chapter is concerned with important target characteristics for passive and active underwater acoustic detection systems. A definition of system performance relative to the objectives of acoustic systems is used in Chapter 13 to provide estimates of certain

parameters (size, bearing, velocity); statistical hypothesis testing is required. The last chapter uses target characteristics, ocean medium, and detection/estimation theory developed earlier in the book to present examples of system performance analysis.

Each chapter except the first contains problems for the interested reader to test his understanding of the material. It is unfortunate that answers are not included somewhere within the text. All chapters contain a suggested reading list for further study. Because of the coverage material, this book will be compared to Urick's *Principles of Underwater Sound*.

Those who want or need an introduction to underwater acoustic system analysis will be interested in this book. It is also appropriate for advanced undergraduate or graduate students in this area.

V.R. Miller
5331 Pathview Drive
Huber Heights, OH 45424

STRUCTURAL MODELING AND EXPERIMENTAL TECHNIQUES

This book treats structural engineering modeling techniques of reinforced and prestressed concrete structures. It is part of a Prentice-Hall series in engineering and engineering mechanics. Emphasis is on applications in research and design. The text draws together recent literature as well as other work in the form of research reports and papers.

The first two chapters discuss the historical background of models relative to their design, testing, and analysis. The limitations, problems, and usefulness of elastic models in certain situations are dealt with in Chapter three. One of the most difficult steps in the modeling process is the accurate representation of material proper-

ties. Chapters four and five treat the models used for reinforced concrete. Scaling effects are always a problem because of the critical effects they can cause; scale effects are presented in Chapter six. Laboratory techniques and loading methods are given in Chapter seven. Strain measurement and interpretation are presented in an introduction to instrumentation techniques in Chapter eight.

As with any modeling technique reliability of results is important, as are random errors that may be introduced in the process. Chapter nine covers the accuracy of reliability modeling. Chapter 10 presents case studies of a wide spectrum of applications of structural modeling and their uses in design and research. Experimental techniques used to study the difficult problem of modeling dynamic loading of structures are presented in Chapter eleven.

This chapter also contains examples of different types of structures under dynamic loading.

Several of the chapters contain problems for the interested reader. Unfortunately, no answers are given. Two appendices address dimensional analysis and the use of SI units. An excellent list of references is given at the end of the book.

Professionals engaged in model analysis and experimental methods should find this text a valuable source of information. It should also be of interest to those responsible for instrumenting test structures, regardless of their size.

V.R. Miller
5331 Pathview Drive
Huber Heights, OH 45424

SHORT COURSES

MACHINERY INSTRUMENTATION AND DIAGNOSTICS

Dates: October 8-11, 1985
Place: Philadelphia, Pennsylvania
Dates: October 21-25, 1985
Place: Carson City, Nevada
Dates: November 5-8, 1985
Place: Boston, Massachusetts
Dates: December 3-6, 1985
Place: Houston, Texas

Objective: This course is designed for industry personnel who are involved in machinery analysis programs. Seminar topics include a review of transducers and monitoring systems, machinery malfunction diagnosis, data acquisition and reduction instruments, and the application of relative and seismic transducers to various types of rotating machinery.

Contact: Customer Information Center, Bently Nevada Corporation, P.O. Box 157, Minden, NV 89423 - (702) 782-3611, Ext. 9242.

UNDERWATER ACOUSTICS AND SIGNAL PROCESSING

Dates: October 21-25, 1985
Place: University Park, Pennsylvania

Objective: The course is designed to provide a broad, comprehensive introduction to important topics in underwater acoustics and signal processing. The primary goal is to give participants a practical understanding of fundamental concepts, along with an appreciation of current research and development activities. Included among the topics offered in this course are: an introduction to acoustic and sonar concepts; transucers and arrays, and turbulent and cavitation noise; an extensive overview of sound propagation modeling and measurement techniques; a physical description of the environment factors affecting deep and shallow water acoustics; a practical guide to sonar electronics; and a tutorial review of analog and digital signal processing techniques and active echo location developments.

Contact: Alan D. Stuart, Course Chairman, Applied Research Laboratory, Pennsylvania State University, P.O. Box 30, State College, PA 16804 - (814) 865-7505.

MACHINERY VIBRATION ANALYSIS

Dates: Oct. 29 - Nov. 1, 1985
Place: Oak Brook, Illinois
Dates: February 11-14, 1986
Place: Orlando, Florida
Dates: August 19-22, 1986
Place: New Orleans, Louisiana
Dates: November 11-14, 1986
Place: Chicago, Illinois

Objective: This course emphasizes the role of vibrations in mechanical equipment instrumentation for vibration measurement, techniques for vibration analysis and control, and vibration correction and criteria. Examples and case histories from actual vibration problems in the petroleum, process, chemical, power, paper, and pharmaceutical industries are used to illustrate techniques. Participants have the opportunity to become familiar with these techniques during the workshops. Lecture topics include: spectrum, time domain, modal, and orbital analysis; determination of natural frequency, resonance, and critical speed; vibration analysis of specific mechanical components, equipment, and equipment trains; identification of machine forces and frequencies; basic rotor dynamics including fluid-film bearing characteristics, instabilities, and response to mass unbalance; vibration correction including balancing; vibration control including isolation and damping of installed equipment; selection and use of instrumentation; equipment evaluation techniques; shop testing; and plant predictive and preventive maintenance. This course will be of interest to

plant engineers and technicians who must identify and correct faults in machinery.

Contact: Dr. Ronald L. Eshleman, Director, The Vibration Institute, 101 West 55th Street, Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254.

VIBRATIONS OF RECIPROCATING MACHINERY

Dates: Oct. 29 - Nov. 1, 1985
Place: Oak Brook, Illinois
Dates: August 19-22, 1986
Place: *New Orleans, Louisiana*
Objective: This course on vibrations of reciprocating machinery includes piping and foundations. Equipment that will be addressed includes reciprocating compressors and pumps as well as engines of all types. Engineering problems will be discussed from the point of view of computation and measurement. Basic pulsation theory --including pulsations in reciprocating compressors and piping systems -- will be described. Acoustic resonance phenomena and digital acoustic simulation in piping will be reviewed. Calculations of piping vibration and stress will be illustrated with examples and case histories. Torsional vibrations of systems containing engines and pumps, compressors, and generators, including gearboxes and fluid drives, will be covered. Factors that should be considered during the design and analysis of foundations for engines and compressors will be discussed. Practical aspects of the vibrations of reciprocating machinery will be emphasized. Case histories and examples will be presented to illustrate techniques.

Contact: Dr. Ronald L. Eshleman, Director, The Vibration Institute, 101 West 55th Street, Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254.

NOVEMBER

MACHINERY INSTRUMENTATION

Dates: November 12-14, 1985
Place: Calgary, Alberta, Canada
Objective: This seminar provides an in-depth examination of vibration measure-

ment and machinery information *systems* as well as an introduction to diagnostic instrumentation. The three-day seminar is designed for mechanical, instrumentation, and operations personnel who require a general knowledge of machinery informa-tion systems. The seminar is a recommended prerequisite for the Machinery Instrumentation and Diagnostics Seminar and the Mechanical Engineering Seminar.

Contact: Customer Information Center, Bently Nevada Corporation, P.O. Box 157, Minden, NV 89423 - (702) 782-3611, Ext. 9243.

DECEMBER

VIBRATION AND SHOCK SURVIVABILITY, TESTING, MEASUREMENT, ANALYSIS, AND CALIBRATION

Dates: December 2-6, 1985
Place: Santa Barbara, California
Dates: February 3-7, 1986
Place: Santa Barbara, California
Dates: March 10-14, 1986
Place: Washington, DC
Dates: May 12-16, 1986
Place: Detroit, Michigan
Dates: June 2-6, 1986
Place: Santa Barbara, California
Dates: August 18-22, 1986
Place: Santa Barbara, California
Objective: Topics to be covered are resonance and fragility phenomena, and environmental vibration and shock measurement and analysis; also vibration and shock environmental testing to prove survivability. This course will concentrate upon equipments and techniques, rather than upon mathematics and theory.

Contact: Wayne Tustin, 22 East Los Olivos Street, Santa Barbara, CA 93105 -(805) 682-7171.

MARCH

MEASUREMENT SYSTEMS ENGINEERING

Dates: March 10-14, 1986
Place: Phoenix, Arizona

MEASUREMENT SYSTEMS DYNAMICS
Dates: March 17-21, 1986
Place: Phoenix, Arizona
Objective: Electrical measurements of mechanical and thermal quantities are presented through the new and unique "Unified Approach to the Engineering of Measurement Systems." Test requestors, designers, theoretical analysts, managers and experimental groups are the audience for which these programs have been designed. Cost-effective, valid data in the field and in the laboratory, are emphasized. Not only how to do that job, but how to tell when it's been done right.

Contact: Peter K. Stein, Director, 5602 East Monte Rosa, Phoenix, AZ 85018 - (602) 945-4603; (602) 947-6333.

JULY

ROTOR DYNAMICS
Dates: July 14-18, 1986
Place: Rindge, New Hampshire
Objective: The role of rotor/bearing technology in the design, development and diagnostics of industrial machinery will be elaborated. The fundamentals of rotor dynamics; fluid-film bearings; and measurement, analytical, and computational techniques will be presented. The computation and measurement of critical speeds vibration response, and stability of rotor/bearing systems will be discussed in detail. Finite elements and transfer matrix modeling will be related to computation on mainframe

computers, minicomputers, and microprocessors. Modeling and computation of transient rotor behavior and nonlinear fluid-film bearing behavior will be described. Sessions will be devoted to flexible rotor balancing including turbogenerator rotors, bow behavior, squeeze-film dampers for turbomachinery, advanced concepts in troubleshooting and instrumentation, and case histories involving the power and petrochemical industries.

Contact: Dr. Ronald L. Eshleman, Director, The Vibration Institute, 101 West 55th Street, Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254.

SEPTEMBER

MODAL TESTING OF MACHINES AND STRUCTURES
Dates: September 8-11, 1986
Place: Chicago, Illinois
Objective: Vibration testing and analysis associated with machines and structures will be discussed in detail. Practical examples will be given to illustrate important concepts. Theory and test philosophy of modal techniques, methods for mobility measurements, methods for analyzing mobility data, mathematical modeling from mobility data, and applications of modal test results will be presented.

Contact: Dr. Ronald L. Eshleman, Director, The Vibration Institute, 101 West 55th Street, Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254.

NEWS BRIEFS: news on current and Future Shock and Vibration activities and events

WORLD CONGRESS ON COMPUTATIONAL MECHANICS
September 22-25, 1986
Austin, Texas

The International Association of Computational Mechanics announces its first World Congress on Computational Mechanics to be held September 22-25, 1986 at The University of Texas at Austin. Host of the Congress will be the Texas Institute for Computational Mechanics (TICOM) and The George Washington University. Several other societies will also contribute support to this meeting. The meeting will bring together researchers in computational methods from many diverse areas including civil engineering, computational fluid mechanics, computational structural mechanics, control theory, applied mathematics, and supporting areas. There will also be sessions on artificial intelligence, expert systems, parallel computing, and displays of new hardware and software by various commercial firms is expected.

For further information contact: WCCM/TICOM, The University of Texas at Austin, Austin, TX 78712.

ABSTRACTS FROM
THE CURRENT LITERATURE

ABSTRACT CONTENTS

AVAILABILITY OF PUBLICATIONS ABSTRACTED

None of the publications are available at SVIC or at the Vibration Institute, except those generated by either organization.

Periodical articles, society papers, and papers presented at conferences may be obtained at the Engineering Societies Library, 345 East 47th Street, New York, NY 10017; or Library of Congress, Washington, D.C., when not available in local or company libraries.

Government reports may be purchased from National Technical Information Service, Springfield, VA 22161. They are identified at the end of bibliographic citation by an NTIS order number with prefixes such as AD, N, NTIS, PB, DE, NUREG, DOE, and ERATL.

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A List of Periodicals Scanned is published in issues, 1, 6, and 12.

MECHANICAL SYSTEMS

ROTATING MACHINES

85-1757
Rotordynamic Analysis of the SSME Turbo-pumps Using Reduced Models
S.T. Noah
Texas A&M Univ., College Station, TX
Rept. No. CR-171170, 72 pp (Sept 1984),
N85-10355/4/GAR

KEY WORDS: Rotors, Spacecraft components, Rocket engines, Pumps

Alternative methods for the rotor-dynamic and sensitivity analysis of large rotor systems are examined. The methods are assessed for their ability to utilize accurate models of reduced size along with effective procedures for describing the dynamic behavior of the systems. Frequency response-based techniques are developed for determining the steady state response to imbalance of the space shuttle main engine (SSME) turbopumps and the related eigenvalue problem.

85-1758
Singular Asymptotic Expansions in Nonlinear Rotordynamics
W.B. Day
Auburn Univ., AL
Rept. No. NASA-CR-174012, 24 pp (Aug 10, 1984), N85-10100/4/GAR

KEY WORDS: Rotors, Spacecraft components, Rocket engines, Pumps

During hot firing ground testing of the Space Shuttle's Main Engine, vibrations of the liquid oxygen pump occur at frequencies which cannot be explained by the linear Jeffcott model of the rotor The model becomes nonlinear after accounting for deadband, side forces, and rubbing. Two phenomena present in the numerical solutions of the differential equations are unexpected periodic orbits of the rotor and

tracking of the nonlinear frequency. A multiple scale asymptotic expansion of the differential equations is used to given an analytic explanation of these characteristics.

85-1759
Avoiding Errors in Critical-Speed Predictions
R.J. Iannuzzelli
Sperry Corp., Blue Bell, PA
Mach. Des., 57 (9), pp 83-86 (Apr 25, 1985), 5 figs

KEY WORDS: Critical speeds, Damped structures

Two basic methods are available for predicting critical speeds. Unfortunately, these techniques cannot always be used interchangeably. When rotating systems are significantly damped, a correction factor must be included in computations to eliminate certain discrepancies. This paper reviews the calculation procedures.

85-1760
Extended Aeroelastic Analysis for Helicopter Rotors with Prescribed Hub Motion and Blade Appended Pendulum Vibration Absorbers
R.L. Bielawa
United Technologies Res. Ctr., East Hartford, CT
Rept. No. NASA-CR-172455, 217 pp (Dec 1984), N85-12038/4/GAR

KEY WORDS: Helicopters, Rotors, Vibration absorption (equipment)

The mathematical development for the expanded capabilities of the G400 rotor aeroelastic analysis was examined. The G400PA expanded analysis simulates the dynamics of all conventional rotors, blade pendulum vibration absorbers, and the higher harmonic excitations resulting from prescribed vibratory hub motions and higher harmonic blade pitch control. The methodology for modeling the unsteady stalled airloads of two dimensional airfoils is discussed. Formulations for calculating the

rotor impedance matrix appropriate to the higher harmonic blade excitations are outlined. Updates to the development of the original G400 theory, program documentation, user instructions and information are presented.

shaft is assumed to be non-linear. First the free vibrations of this rotor are analyzed analytically and numerically. The results are compared. After that the vibrations in the non-resonant case are analyzed. The solution is found by use of the analytical method of multiple scales. The results for free vibrations and for the non-resonant case are compared.

85-1761

Natural Frequencies of Twisted Rotating Plates

V. Ramamurti   R. Kielb
Indian Inst. of Technology, Madras 600036, India
J. Sound Vib., 97 (3), pp 429-449 (Dec 9, 1984), 14 figs, 15 tables, 20 refs

KEY WORDS: Rotors, Plates, Natural frequencies

A detailed comparison is presented of the predicted eigenfrequencies of twisted rotating plates as obtained by using two different shape functions. Primarily, rotating twisted plates of two different aspect ratios and two different thickness ratios are considered. The effects of rotation are included by using a "stress smoothing" technique when calculating the augmented stiffness matrix. In addition, the effects of Coriolis acceleration, contributions from membrane behavior, setting angle and sweep angle are considered. The effects of geometric nonlinearity are briefly discussed. Finally, results of a brief study of cambered plates are presented.

85-1762

Vibrations of a Textile Machine Rotor

L. Cveticanin
Univ. of Novi Sad, 21000 Novi Sad, V. Vlahovica 3, Yugoslavia
J. Sound Vib., 97 (2), pp 181-187 (Nov 22, 1984), 7 figs, 5 refs

KEY WORDS: Shafts, Rotors, Textiles

In this paper the vibrations of a textile machine rotor, whose angular velocity is constant, are analyzed. The function of the rotor is to wind up a band of textile material into a roll. The elastic force in the

85-1763

Unsteady Flows in Axial-Flow Compressors and a Mathematical Noise Model for the Subsonic Range (Instationare (Stromungen in Axialverdichtern und ein mathematisches Larmmodell fur den Unterschallbereich)

J. Jedryszek
Technische Hochschule Wroclaw (VR Polen), Institut fur Warmetechnik und Flussigkeitsmechanik
Maschinenbautechnik, 34 (2), pp 90-93 (1985), 9 figs, 11 refs (In German)

KEY WORDS: Compressors, Noise generation

Unsteady pressures and velocities at the after guide-blade-profiles of an axial-flow ventilator are calculated for weakly curved compressor lattices. They are compared with experimental results. The unsteady effects within the axial gap planes and on the blade surfaces as well as the noise level of the stage are gauged. The gauged unsteady pressures and noise levels of the stage agree rather exactly with theoretical calculations.

85-1764

Alignment Changes and Their Effects on the Operation and Integrity of Large Turbine Generators: Experience in the CEGB South Eastern Region

Y. Hashemi
Central Electricity Generating Board, London, UK
Steam and Gas Turbine Foundations and Shaft Alignment Conf. Feb 24, 1983, London, UK. Spons. The Power Industries Div. of IMechE., IMechE Conf. Pubs 1983-1, pp 19-30, 9 figs, 4 tables, 9 refs

KEY WORDS: Steam turbines, Generators, Alignment

A number of the factors which can lead to alignment changes in steam turbine generators and their effects on the rotor-bearing interactions are discussed. Some of the operational difficulties associated with mis-alignments are described and the actions which can be taken to overcome them are illustrated by reference to experience obtained from turbine plant in the SE Region of the CEGB.

85-1765
A Note on Tower Wake/Blade Interaction Noise of a Wind Turbine
S. Fujii, K. Takeda, H. Nishiwaki
National Aerospace Lab., Chofu, Tokyo, Japan
J. Sound Vib., 97 (2), pp 333-336 (Nov 22, 1984), 3 figs, 1 ref

KEY WORDS: Wind turbines, Noise generation

Experimental observations on wind turbine tower wake/blade interaction noise are presented. Results for circular, elliptical and square sections of the support tower legs are compared and quantified with respect to the acoustic frequency spectra produced. The results are preliminary ones obtained in a continuing study aimed at constructing a shape that may yield a lower interaction noise.

85-1766
Turbine Generator Alignment Using a Laser-Based Optical System
A.J. Batterham
Central Electricity Generating Board, Bristol, UK
Steam and Gas Turbine Foundations and Shaft Alignment Conf. Feb 24, 1983, London, UK. Spons. The Power Industries Div. of IMechE., IMechE Conf. Pub. 1983-1, pp 53-62, 6 figs, 1 table

KEY WORDS: Turbogenerators, Alignment, Lasers

A laser-based system has been adapted for aligning large turbine generators. Site trials have shown it is safe and accurate in use.. It is anticipated that plant outage times could be reduced by speeding the alignment process.

85-1767
Economical Optimisation of the Alignment of Turbine Generators
W.G.R. Davies, P.C. Pandey
Central Electricity Generating Board, Nottingham, UK
Steam and Gas Turbine Foundations and Shaft Alignment Conf., Feb 24, 1983, London, UK. Spons. by The Power Industries Div. of IMechE., IMechE Conf. Pub. 1983-1, pp 45-52, 5 figs, 6 tables

KEY WORDS: Turbogenerators, Alignment, Computer programs

In realigning a large multi-bearing turbine generator, it is important to minimize the amount of work involved. This can sometimes be achieved by reducing the number and magnitude of bearing height changes, even though this may leave one or more bearings misaligned with respect to the ideal catenary. A mathematical formulation has been derived to allow this procedure to be optimized, in two stages.

85-1768
Fatigue Reliability of Gas Turbine Engine Components Under Scheduled Inspection Maintenance
J.N. Yang, S. Chen
The George Washington Univ., Washington, D.C.
J. Aircraft, 22 (5), pp 415-422 (May 1985), 6 figs, 2 tables, 27 refs

KEY WORDS: Turbine engines, Turbine components, Fatigue life

A probabilistic method is developed for the fatigue reliability analysis of gas turbine engine components under scheduled inspection maintenance in service. Various statistical uncertainties involved in the complex

design system of gas turbine engine compo-
nents have been taken into account, includ-
ing the time to crack initiation, fatigue
crack propagation, service loads, crack
modeling, crack geometry, nondestructive
evaluation (NDE), etc. It is demonstrated
that the service inspection maintenance can
be used to improve the reliability of fa-
tigue-critical components significantly. An
example for the third-stage turbine disk of
a TF-33 jet engine has been worked out to
demonstrate the application of the analysis
methodology developed.

in the mass flow rate may not correspond
with higher energy efficiencies. In this
paper a computer simulation program is
described, which includes the manifold back
pressure effect, developed to investigate and
explain the tuning phenomena for a single
or two-cylinder reciprocating compressor.

METAL WORKING AND FORMING

85-1769
**Study on Dynamic Characteristics of Liquid
Oxygen Pumps for Rocket Engines**
T. Shimura, K. Kamijo
National Aerospace Lab., Tokyo, Japan
Rept. No. NAL-TR-806, 11 pp (Apr 1984),
N85-12088/9/GAR (In Japanese)

KEY WORDS: Rocket engines, Pumps

Transfer matrix methods, which were ap-
plied to cavitating inducers, are used in
order to examine the dynamic response of a
centrifugal liquid oxygen pump with an
inducer.

85-1771
**Noise Reduction of the Exhaust from Pneu-
matic Tools**
G. Lorenz
Inst. fuer Werkzeugmaschinen, Stuttgart
Univ., Fed. Rep. Germany
Rept. No. BMFT-FB-HA-183-21, 100 pp
(Sept 1983), N85-11799

KEY WORDS: Machine tools, Noise reduc-
tion

Noise in the vane type air motor is exam-
ined. Pressure pulses in the exhaust,
caused by the thermodynamic cycles from
the chambers and their periodic exhaust,
are found to be the main causes of the
noise. A silencer for the discrete frequen-
cy noise was developed.

RECIPROCATING MACHINES

85-1770
**A Computer Simulation Study of Compres-
sor Tuning Phenomena**
J.J. Nieter, R. Singh
Ohio State Univ., Columbus, OH 43210
J. Sound Vib., 97 (3), pp 475-488 (Dec 8,
1984), 9 figs, 1 tables, 21 refs

KEY WORDS: Reciprocating compressors,
Tuning, Acoustic pulses, Computerized
simulation

Basic thermofluid processes of a positive
displacement compressor are strongly de-
pendent upon the acoustic behavior of the
manifolds. The tuning process of such a
compressor is fairly complex as increases

85-1772
**Modal Displacement Vectors Describing the
Relative Behaviour on the Given Point.
(Modalverlagerungsvektoren beschreiben
Relativverhalten in der Wirkstelle)**
H. Tonshoff, W. Kiehl, S. Bohao
Hannover, Fed. Rep. Germany
VDI-Z, 126 (18), pp 657-662 (1984), 7 figs,
1 table, 7 refs (In German)

KEY WORDS: Machine tools, Modal analysis

Modal analysis is an important aid for in-
vestigating the dynamic behavior of me-
chanical structures. By this means the
modal parameters of natural frequency,
compliance, phase angle, attenuation and
mass of complex systems can be determined
from experimentally calculated transfer

function. Machine tools also pertain to this category. The method of modal displacement vectors is developed in this paper. This is suitable for progressive analysis of modal parameters and allows consideration for the relative movements between tool and workpiece as a function of the vibration behavior of a given weak point. The method also provides pointers for optimal layout of machine elements.

of positioning automatic control loops is dependent on the lowest natural frequency of mechanical transmission elements. It must be tuned to the characteristic angular frequency of the automatic drive control loop. Plain evaluation possibilities for the fundamental frequency of the mechanical transmission system are stated, which can also be handled as a dimensioning base.

85-1773
Theoretical and Experimental Modal Analysis of a Machine Tool-Drive System (Rechnerische und experimentelle Modalanalyse einer Werkzeugmaschinen-Antriebsstruktur)
J. Milberg, H. Summer
Institut fur Werkzeugmaschinen und Betriebswissenschaften der Technischen Universitat Munchen, Fed. Rep. Germany

KEY WORDS: Machine tools, Modal analysis

Static and dynamic flexibility of a prestressed machine tool-drive system is calculated. The calculations are compared with an experimental modal analysis. In order to compare the two methods quantitatively, the dynamic deflections in their undamped state are determined.

85-1774
Designing Demands to Feed Axes and Frame Components of Machine Tools with Continuous-Path Control of High Accuracy
K. Grossmann
VEB Mikromat, Dresden

KEY WORDS: Machine tools, Automatic control

The analysis of stability behavior and response to a variation of the reference input

85-1775
Vibrations Increase Available Power at the Bit
D.W. Dareing
Norton Christensen Drilling Products, Houston, TX 77073

KEY WORDS: Drills, Fatigue life

Drillstring vibrations are generally considered to be detrimental to downhole drilling equipment because they produce cyclic or fatigue loading. Tool joint failures, tubular washouts, and bit breakage are often fatigue related. On the positive side, dynamic forces applied to roller cone rock bits have the potential to increase penetration rate. This paper quantifies the available vibration energy at the bit and shows how to control the level of energy through bottom hole assembly design and rotary speed.

85-1776
Modeling and Analysis of Flow-Induced Vibrations in Circular Saws
M.C. Leu, M. Jirapongphan
Cornell Univ., Ithaca, NY

KEY WORDS: Circular saws, Fluid-induced vibration, Random vibration, Resonant response

Two types of flow-induced vibrations in idling circular saws, random vibration and resonant vibration, were modeled and ana-

lyzed. The excitation source, which is the flow pressure fluctuations, was modeled as discrete forces acting at the saw teeth. The response was assumed to be uncoupled from the excitation in the random vibration analysis but coupled with the excitation in the resonant vibration analysis. The random vibration was solved in terms of statistical rms amplitudes and the resonant vibration as a time function. The analytical results captured many characteristics of vibration phenomena observed in idling saw experiments.

MATERIALS HANDLING EQUIPMENT

85-1777
Design and Operating Criteria for vibratory Bowl Feeder (Auslegungs- und Betriebskriterien für Vibrationswendelforderer
H. Ahrens
VDI-Z, *126* (22), pp 881-884 (1984), 7 figs, 1 table, 3 refs (In German)

KEY WORDS: Oscillating conveyors

For correct workpiece control on automated production and assembly lines the vibratory bowl feeder is the most frequently employed manipulating device. For making purposeful equipment design possible, the basic influencing factors and their mutual dependencies for the feeder processes in vibratory bowl feeders as design criteria are described. The actual working motion of vibratory bowl feeding is outlined and some basic conditions to be maintained for the vibratory system and the erection of the device are presented.

85-1778
Vibratory Feeding by Nonsinusoidal Vibration - Optimum Wave Form
S. Okabe, Y. Kamiya, K. Tsujikado, Y. Yokoyama
Kanazawa Univ., Kanazawa, Japan
J. Vib., Acoust., Stress, Rel. Des., Trans. ASME *107* (2), pp 188-195 (Apr 1985), 14 figs, 10 refs

KEY WORDS: Vibrators (machinery), Conveyors, Random excitation, Materials handling equipment

This paper presents the conveying velocity on a vibratory conveyor whose track is vibrated by nonsinusoidal vibration. The velocity wave form of the vibrating track is approximated by six straight lines, and five distortion factors of the wave form are defined. Considering the modes of motion of the particle, the mean conveying velocity is calculated for various conditions. Referring to these results, the optimum wave form is clarified analytically. The theoretical results are confirmed by experimental results.

85-1779
Dynamic Models for Control System Design of Integrated Robot and Drive Systems
M.C. Good, L.M. Sweet, K.L. Strobel
General Electric Co., Schenectady, NY 12345
J. Dynam. Syst., Meas. Control, Trans. ASME, *107* (1), pp 53-59 (Mar 1985) 10 figs, 18 refs

KEY WORDS: Robots, Linkages

This paper presents analytical models and experimental data to show that interactions between electromechanical drives coupled with compliant linkages to arm link drive points are of fundamental importance to robot control system design. Flexibility in harmonic drives produces resonances in the 5 Hz to 8 Hz range. Flexibility in the robot linkages and joints connecting essentially rigid arm members produces higher frequency modes at 14 Hz and 40 Hz. The nonlinear characteristics of the drive system are modeled, and compared to experimental data. The models presented have been validated over the frequency range 0 to 50 Hz. The paper concludes with a brief discussion of the influence of model characteristics on motion control design.

STRUCTURAL SYSTEMS

BRIDGES

85-1780

Feasibility Investigation of Utilizing the Internal Friction Damping Nondestructive Evaluation Technique (IFD-NDE) for Measuring the Degree of Fatigue in Mobile Bridge Structures

R.S. Weinreich
Daedalean Associates, Inc., Woodbine, MD

KEY WORDS: Bridges, Fatigue tests, Internal friction, Coulomb friction, Nondestructive tests

This report discusses a nondestructive test technique which has the potential for measuring the degree of fatigue in military bridge structures.

85-1781

Dynamic Investigations of Large Bridges, in-situ Tests and Mathematical Models (Dynamische Untersuchungen von Grossbrucken, in situ- Versuche und Rechenmodelle)

K. Kernbichler, R. Flesch, G. Rauscher
Technisches Universitat-Graz, Austria

KEY WORDS: Bridges, Testing techniques, Mathematical models

The dynamic behavior of bridges was investigated. The investigations consisted of dynamic in-situ tests and calculations. The aim is to improve the mathematical model for the analysis of dynamic loads. The development of a dynamic procedure for the inspection of the construction is reported.

85-1782

Aerodynamic Stability of Cable-Stayed Bridge with New Vierendeel-Type Girder

Y. Nakayama
Nippon Kokan K.K. 1-1-2, Marunouchi, Chiyoda-ku, Tokyo 100, Japan

KEY WORDS: Bridges, Cable stayed structures, Aerodynamic loads, Flutter

An aerodynamic study is described showing the stability of a new type of double deck cable-stayed bridge having both upper and lower flat, shallow, streamlined box girder decks connected by vertical members only. The three aerodynamic components of force have also been measured. For comparison, a wind-tunnel experiment has been carried out using a partial model of a conventional suspended structure of a typical truss type double deck cable-stayed bridge. It is shown that the new system is superior to the truss type from an aerodynamic stability viewpoint.

85-1783

Vehicle-Bridge Interaction

T. Dahlberg
Chalmers Univ. of Technology, S-412 96 Gothenburg, Sweden

KEY WORDS: Bridges, Moving loads, High speed transportation systems, Railroad trains

A method for estimation of the time-dependent vehicle-bridge interaction forces has been developed in the present The increase (or decrease) of the bridge response due to dynamic effects is determined. The moving constant-force problem is reviewed in some detail. Results obtained by the present method for the moving-mass problem are compared with existing experimental and theoretical results as reported in the literature. A parametric study of bridge responses is made.

85-1784
Dynamic Interaction Between Freight Train and Steel Bridge
M.H. Bhatti, V.K. Garg, K.H. Chu
GDS and Associates, Consulting Engineers, Chicago, IL
J. Dynam. Syst., Meas. Control, Trans. ASME, 107 (1), pp 60-66 (Mar 1985), 10 figs, 2 tables, 21 refs

KEY WORDS: Bridges, Moving loads, Railroad trains, Freight cars

The dynamic responses of a railway steel bridge due to vehicle-track-bridge interaction were investigated for the effects of vertical and lateral track irregularities, approach track quality, vehicle weight and type, and train speed. It was found that greater approach irregularities produce higher impact factors and dynamic forces in bridge members. Light weight and empty cars produce higher impact factors but small dynamic forces. Impact factors depend on such parameters as axle spacing, suspension system stiffness, and truck center distances.

BUILDINGS

85-1785
Modeling of Buildings for Earthquake Analysis (Modellierung von Gebauden fur Erdbebenanalysen)
J.G. Bouwkamp, J. Kollegger
Univ. of California, Berkeley, CA
Dynamische Probleme. Modellierung und Wirklichkeit. Proc. mtg. Oct 4-5, 1984, Hannover, Curt-Risch-Institut der Universitat Hannover, Hannover, Fed. Rep. Germany, Vol. II, pp 519-536, 14 figs, 5 tables, 11 refs (In German)

KEY WORDS: Multistory buildings, Seismic response, Mathematical models

A procedure developed for the determination of vibration response of multistory buildings is illustrated by testing natural and forced vibrations of a twelve story residential slab building. Comparison with calculations showed a large effect of ground

deformation on the dynamic properties of the mathematical models. The flexibility of the soil was determined by the addition of another floor, whose height and stiffness were determined from the experimental data. Also available information from a foundation investigation was used. This model produced excellent agreement of experimental and analytical results.

85-1786
Vibration and Noise Reduction in a Building Above an Underground Train Tunnel (Erschutterungs- und Schallschutzmassnahmen fur ein Gebaude uber einem S-Bahn-Tunnel)
H. Grundmann, F.H. Muller, R. Muller
Technische Universitat Munchen, Fed. Rep. Germany
Dynamische Probleme. Modellierung und Wirklichkeit. Proc. mtg., Oct 4-5, 1984, Hannover, Curt-Risch-Institut der Universitat Hannover, Hannover, Fed. Rep. Germany, Vol. I, pp 215-232, 8 figs, 6 refs (In German)

KEY WORDS: Buildings, Noise reduction, Design techniques

A brief description of the problem in constructing a residential commercial building above an underground train tunnel is given. Calculations for damping structural noise in the building are presented.

85-1787
Earthquake Safety of Ductile Beam Frameworks (Zur Erdbebensicherheit duktiler Strabtragwerke)
U. Hohlsiepe, W.B. Kratzig, K. Meskouris
Lehrstuhl KIB III - Statik und Dynamik -der Ruhr-Universitat Bochum, Fed. Rep. Germany
Dynamische Probleme. Modellierung und Wirklichkeit. Proc. mtg., Oct 4-5, 1984, Hannover, Curt-Risch-Institut der Universitat Hannover, Hannover, Fed. Rep. Germany, Vol. I, pp 261-278, 17 figs, 6 refs (In German)

45

A multistory building can sustain a much higher earthquake-induced excitations than it its design indicates if there is sufficient ductility at the critical points of the framework. To attain such construction requirements a method for a nonlinear response calculation is presented. It takes into consideration inelastic framework characteristics in which the supports remain in the elastic range while a considerable amount of seismic energy is dissipated by the yield hinges in the beams. By a proper choice of stiffness and ductility characteristics the engineer is able to design into the structure an unusually high degree of seismic safety.

85-1788
Dynamic Response of Multistoried Brick Buildings
M. Qamaruddin, A.S. Arya, B. Chandra
Univ. of Petroleum and Minerals, Dhahran, Saudi Arabia

The paper presents the seismic response analysis of a typical multistoried brick building. A number of variables representing the physical properties of the structural system, namely, number of stories from one to four, wall thickness in various stories from one to one and a half brick thick and damping from 5 per cent to 15 per cent of critical value are considered. From this study the critical sections for providing reinforcing have been identified and the minimum amount of necessary steel has been estimated.

TOWERS

85-1789
Effects of Load Modelling on Dynamic Response: Articulated Tower
A. Bech, B.J. Leira

This report details the effects of using actual versus static positions as a basis for wave force calculations. An articulated tower has been studied, both by means of simplified analytical considerations and a numerical computer program. It is concluded that the effects of using instantaneous positions may be significant considering both load and response.

FOUNDATIONS

85-1790
Inelastic Seismic Response of Simple Eccentric Structures
W.K. Tso, A.W. Sadek
McMaster Univ., Hamilton, Ontario, Canada

The maximum ductility demand and the edge displacement of a simple single mass eccentric model is evaluated when the system is subjected to ground motions represented by the El Centro 1940 and Taft 1952 earthquake records. The resisting elements are taken to be bilinear hysteretic. It is found that the ductility demand depends to a great extent on the energy content of the ground motions, particularly in the period range beyond the elastic period of the system.

85-1791
Dynamic Slope Stability Analyses with a Non-Linear Finite Element Method
K. Toki, F. Miura, Y. Oguni

A new technique is presented with which to investigate slope stability during strong earthquake motion. This technique is based on a non-linear finite element method that uses a joint element to express non-linear behavior and the progressive failure of a slope. Joint elements are arranged at every interface between soil elements. The method was used to investigate the stability of an existing slope during strong earthquake motions. Preliminary static analyses were made, and their results were compared with results obtained with Janbu's method in order to check the validity of our proposed method.

85-1792
Operating Mode: Determination of Dynamic Soil Modules by Resonance (Mode Operatoire: Determination des Modules Dynamiques des Sols par Resonance)
Centre de Recherches Routieres, Brussels, Belgium
Rept. No. MF-51/84, 54 pp (1984) PB85-136463/GAR (In French)

KEY WORDS: Soils, Vibration tests, Testing techniques

Determination of dynamic soil modules by resonance means subjecting a cylindrical soil sample of known length and volume mass at its base to sinusoidal vibrations. They are maintained longitudinally or in twist, at increasing frequency.

85-1793
Preventative Design/Construction Criteria for Turbomachinery Foundations
E.M. Renfro
Adhesive Services Co., Houston, TX
Steam and Gas Turbine Foundations and
Shaft Alignment Conf. Feb 24, 1983, Lon-

The time to reduce maintenance costs on turbomachinery is in the design and construction stages. Faulty support ultimately results in alignment or vibration problems. These conditions in turn erode reliability and at the same time render increased maintenance costs. Support problems occur on equipment mounted on structural steel platforms, sometimes called baseplates, as well as on conventional concrete block mounted equipment. Common weaknesses of baseplates are examined with emphasis placed on the non-rigidity of typical baseplates, distortion due to loading and warping from piping stresses or thermal expansion.

85-1794
The Dynamics of Turbo-Alternator Foundations
A.W. Lees, I.C. Simpson
Central Electricity Generating Board, Bristol, UK
Steam and Gas Turbine Foundations and
Shaft Alignment Conf., Feb. 24, 1983,
London, UK. Spons. by The Power Industries Div. of IMechE., IMechE Conf. Pub.
1983-1, pp 37-44, 5 figs, 1 ref

KEY WORDS: Machine foundations, Turbomachinery

A review is given of the field of turbo alternator foundation dynamics. The results of both plant tests and theoretical studies which have been carried out over the past 15 years are examined.

85-1795
Foundation and Alignment Problems of Small Machines
L.F. Moore
Leslie F. Moore Associates, Dartford, Kent, UK

Steam and Gas Turbine Foundations and Shaft Alignment Conf. Feb 24, 1983, London, UK. Spons. by The Power Industries Div. of IMechE, IMechE Conf. Pub. 1983-1, pp 31-36, 3 figs

KEY WORDS: Machine foundations

This paper examines the reasons for rigidly or resiliently mounting machines and then discusses the merits of the various types of resilient mounting. The controlling parameters are surveyed together with ancillary requirements such as the need for inertia blocks, foundation plinths and holding-down bolts, and piping flexibility.

85-1796
Steel Foundations for the Support of High-Speed Machinery
R.O. Praefcke
MAN Maschinenfabrik Augsburg-Nurnberg, Ginsheim-Gustavsburg, W. Germany
Steam and Gas Turbine Foundations and Shaft Alignment Conf., Feb 24, 1983, London, UK. Spons. by The Power Industries Div. of IMechE., IMechE Conf. Pub. 1983-1, pp 9-18, 8 figs

KEY WORDS: Machinery foundations, Design techniques

Steel foundations have been successfully used to support turbo-generators and other high-speed machinery, generally with rated speeds of 300 ref/min and above. Their design, analysis, characteristics, fabrication, and site erection are described.

85-1797
Dynamic Pile Testing as a Nonlinear System Identification (Dynamische Pfahlprufung als nichtlineare System-identifikation)
O. Klingmuller
Bilfinger & Berger Bau AG, Mannheim, Fed. Rep. Germany
Dynamische Probleme. Modellierung und Wirklichkeit. Proc. of mtg. Oct 4-5, 1984, Hannover, Curt-Risch-Institut der Universitat Hannover, Hannover, Fed. Rep. Germany, Vol. II, pp 537-554, 6 figs, 9 refs (In German)

KEY WORDS: Pile structures, Dynamic tests, Nonlinear theories, System identification techniques

The dynamic pile testing is presented as a problem of nonlinear system identification. After a short introduction to the problem the solvability and the uniqueness of solutions is presented.

85-1798
Generation and Propagation of Excitations Caused by Pile Driving (Entstehung und Ausbreitung von Rammerschutterungen)
H. Hebener, W. Rucker
Bundesanstalt fur Materialprufung (BAM), Berlin, Fed. Rep. Germany
Dynamische Probleme. Modellierung und Wirklichkeit. Proc. mtg., Oct 4-5, 1984, Hannover, Curt-Risch-Institut der Universitat Hannover, Hannover, Fed. Rep. Germany, Vol. I, pp 195-214, 18 figs, 10 refs (In German)

KEY WORDS: Pile driving, Soil-structure interaction, Shock waves, Wave propagation

A theoretical analysis of the boundary conditions between piles and soil is presented using the methods for dynamic bearing strength determination. Mathematical simulation and experimental results from the propagation of impulse excitation in an inhomogenous half space are presented.

85-1799
Numerical Modeling of the Behavior of Water Saturated Soils Under Harmonic and Seismic Excitation (Numerische Modellierung des Verhaltens wassergesattigter Boden unter harmonischer und seismischer Belastung)
J. Strauss, H. Cramer, W. Wunderlich
Ruhruniversitat Bochum, Institut fur Konstruktiven Ingenieurbau, Fed. Rep. Germany
Dynamische Probleme. Modellierung und Wirklichkeit. Proc. mtg. Oct 4-5, 1984, Hannover, Curt-Risch-Institut der Universitat Hannover, Hannover, Fed. Rep. Germany, Vol. I, pp 177-194, 12 figs, 8 refs (In German)

Simulation of the behavior of soils is proposed taking into consideration the tensile strength. Continuous reduction of shear modulus of elasticity up to its ideal plastic range is included. Dependency of the shear modulus and bearing strength on the hydrostatic stress component is considered. The proposed material law is tested by means of the available experimental results. The model is illustrated in an analysis of seismic or aircraft penetration response of nuclear power plants.

85-1800

Non-Linear Soil-Structure-Interaction Analysis Using Green's Function of Soil in the Time Domain

J.P. Wolf, P. Obernhuber
Electrowatt Engrg. Services, Ltd., 8022 Zurich, Switzerland

Contribution of unbounded soil to basic equation of motion of a nonlinear analysis of soil-structure interaction consists of convolution integrals of displacement-force relationship in the time domain and history of interaction forces. The former is calculated using the indirect boundary-element method, which is based on a weighted-residual technique and involves Green's functions. As an example of a nonlinear soil-structure-interaction analysis, the partial uplift of the basemat of a structure is examined.

85-1801

Non-Linear Soil-Structure-Interaction Analysis Using Dynamic Stiffness or Flexibility of Soil in the Time Domain

J.P. Wolf, P. Obernhuber
Electrowatt Engrg. Services Ltd., 8022 Zurich, Switzerland

The dynamic-stiffness or flexibility coefficient in the time domain is calculated as the inverse Fourier transform of the corresponding value in the frequency domain for an irregular soil with the linear unbounded soil.

85-1802

Displacement Solutions for Dynamic Loads in Transversely-Isotropic Stratified Media

G. Waas, H.R. Riggs, H. Werkle
Hochtief AG, Abt. KTI, Bockenheimer Landstr. 24, 6000 Frankfurt/Main 1, W. Germany

Solutions for the displacements caused by dynamic loads in a viscoelastic transversely-isotropic medium are derived. The medium extends horizontally to infinity, but is bounded below by a rigid base. Stratification of the medium presents no difficulties.

POWER PLANTS

85-1803

Comprehensive Vibration Assessment Program for the Prototype System 80 Reactor Internals (Palo Verde Nuclear Generating Station Unit 1)

Combustion Engineering, Inc., Windsor, CT

In accordance with the U.S. Nuclear Regu-
latory Commission Regulatory Guide 1.20
(Rev. 2)a Comprehensive Vibration Assess-
ment Program (CVAP) has been developed
for Palo Verde Nuclear Generating Station
Unit 1. Purpose of the CVAP is to verify
the structural integrity of the reactor inter-
nals to flow induced loads prior to com-
mercial operation. The dynamic flow
related loads considered are associated with
normal steady state operation and antici-
pated operating transients.

85-1804
Seismic Design Criteria and Their Applica-
tion to Major Hazard Plants Within the
United Kingdom
M.A.H.G. Alderson
UKAEA Risley Nuclear Power Development
Establishment, Culcheth, UK

The nature of seismic motions and the
implications are briefly described. The
development of seismic design criteria for
nuclear power plants in various countries is
described. Finally this effect of earth-
quakes on major hazard plant is discussed
in general terms including the seismic anal-
ysis of a typical plant item.

OFF-SHORE STRUCTURES

85-1805
Combined Wind, Wave and Current Forces
— Extreme Value Analysis of a Simplified
Model
A. Naess
Norwegian Hydrodynamic Labs., Hakon
Hakansons gt 34 P.O.B. 4118 Valentinlyst,
N-7001 Trondheim, Norway

Studies are presented on the extreme value
statistics of combined wind, wave and cur-
rent loading on a fixed offshore structure.
The emphasis is on a method developed by
the author to study extreme values of
compound stochastic processes. The effect
on the extreme value estimates of consider-
ing the component loads separately or si-
multaneously is discussed.

85-1806
Coupled Response of Compliant Offshore
Platforms
J.W. Leonard, R.A. Young
Ocean Engrg. Program, Oregon State Univ.,
Corvallis, OR 97331

A three-dimensional finite element analysis
has been used to simulate the coupled static
and dynamic behavior of compliant ocean
structures. Nonlinearities which result from
large deflections, reduced or zero stiffness
in compression, and nonconservative fluid
loading are considered. Also the spatial
variation of fluid loading is addressed.

85-1807
In-Line Forces on Vertical Cylinders in
Deepwater Waves
T.H. Dawson
U.S. Naval Academy, Annapolis, MD 21402

Laboratory measurements of the total in-line
forces on a fixed vertical 2-in-dia cylinder

in deep-water regular and random waves are given and compared with predictions from the Morison equation.

85-1808
Environmental Load Effect Analysis of Guyed Towers
O. Mo, T. Moan
A.S. Veritec, Det norske Veritas, Oslo, Norway
J. Energy Resources Tech., Trans. ASME, 107 (1), pp 24-33 (Mar 1985), 11 figs, 16 refs

KEY WORDS: Off-shore structures, Towers, Guyed structures, Hydrodynamic excitation

A general method for dynamic load effect analysis of slender offshore structures subjected to short crested random waves, current and wind, is given. The structure is a three-dimensional space frame model utilizing dash-pots and linear or nonlinear spring elements to represent guy lines and coupling between structure and foundation. The component mode synthesis formulation is used for reduction of the number of degrees of freedom.

85-1809
Effects of Load Modelling on Dynamic Response: Marine Riser Systems
A. Bech
Selskapet for Industriell og Teknisk Forskning, Norges Tekniske Hoegskole, Trondheim, Norway
Rept. No. STF71-A84013, ISBN-82-595-3454-1, 111 pp (Mar 1984), PB85-124022

KEY WORDS: Marine risers

This report details the effects of using actual static positions as a basis for wave force calculations in riser problems. Two riser systems have been studied: A drilling riser connected to a semi-submersible platform at 325 meters waterdepth. A production riser connected to a tension-legged platform at 350 meters waterdepth.

85-1810
Large Displacement Analysis of a Marine Riser
T. Huang, S. Chucheepsakul
Univ. of Texas, Arlington, TX 76019-308
J. Energy Resources Tech., Trans. ASME, 107 (1), pp 54-59 (Mar 1985), 6 figs, 8 refs

KEY WORDS: Offshore structures, Marine risers

A method of static analysis for a marine riser experiencing large displacements is presented. The method is suitable for analyzing a riser having a known top tension and a possible slippage at the top slip joint. Utilizing the stationary condition of a functional coupled with an equilibrium equation, one can conveniently obtain the equilibrium configuration numerically.

85-1811
Drag Forces on Oscillating Cylinders in a Uniform Flow
M. Kato, T. Abe, M. Tamiya, T. Kumakiri
Kobe Steel, Ltd., Kobe, Japan
J. Energy Resources Tech., Trans. ASME, 107 (1), pp 12-17 (Mar 1985), 8 figs, 2 tables, 14 refs

KEY WORDS: Off-shore structures, Marine risers, Cylinders, Hydrodynamic excitation, Drag coefficients

This paper describes the drag coefficients of cylinders oscillated in both in-line and transverse directions to a uniform flow. The drag coefficients have been obtained experimentally over a wide range of oscillation frequencies, amplitude and flow velocities for the cylinders of various diameters under simulated practical offshore conditions. New expressions are proposed for the drag coefficients of an oscillating cylinder in a uniform flow.

85-1812
Added Mass and In-Line Steady Drag Coefficient of Multiple Risers
T. Overvik, G. Moe
STATOIL, Norway

KEY WORDS: Marine risers, Off-shore structures, Hydrodynamic excitation, Added mass effects, Drag coefficients

Part of the results of an investigation with multiple rise configuration exposed to steady currents are presented. Both the added mass, the frequency of vibration and the in-line steady drag coefficient are discussed both for vibration in the lock-in range and in the galloping mode.

85-1813
Comparisons of Simulation Methods for Motions of a Moored Body in Waves
M. Takagi, K. Saito, S. Nakamura
Hitachi Zosen Corp., Osaka, Japan

KEY WORDS: Moorings, Time domain methods, Simulation

Based on the linear water wave theory, numerical simulations are carried out for motions in waves of a body moored by a nonlinear-type mooring system. Numerical results obtained by using the equation of motion described in the time domain with a convolution integral are compared with those of the second-order linear differential equation with constant coefficients. These results are also compared with experimental values measured from the initial stage.

VEHICLE SYSTEMS

GROUND VEHICLES

85-1814
Dynamics of Double Bottom Commercial Vehicles
M.J. Vanderploeg, J.E. Bernard
The Univ. of Iowa, Iowa City, IA

KEY WORDS: Commercial transportation, Ground vehicles, Stability

The subject of this paper is the double bottom commercial vehicle which, in some configurations, has had severe stability problems. Through a literature review and linear analysis, it is shown that in the so-called Michigan Double configuration, the pup trailer, behaves in a volatile way in a lane change manoeuvre. Various design alternatives are shown to offer some improvement.

85-1815
Gaining a Better Understanding of the Vehicle Dynamics of Commercial Vehicles as a Contribution Towards Improving Active Safety (Entwicklung eines fahrdynamischen Konzeptes fur Nutzfahrzeuge als Beitrag zur aktiven Sicherheit)
E. Gohring, E.C. von Glasner, B. Maier
Anna-Schieber-Weg 43, 7300 Esslingen

KEY WORDS: Ground vehicles, Vehicle-terrain interaction, Impact response

A means of accurately evaluating and optimizing a vehicle's behavior during vertical, lateral and longitudinal dynamic impact is described. This involves analyzing all vehicle components that directly affect the safety of a vehicle, its occupants or others, such as axle suspension, brakes, retarder and tires, for their reaction to the input of disturbing factors. A proper understanding often represents an optimal compromise among all pertinent influences.

85-1816
Immittance Identification: An Application to the Dynamic Modelling of Vehicle Components
N.G. Hemingway

If the dynamic characteristics of a number
of components or sub-systems can be de-
fined then it is possible to predict the vi-
bration characteristics of an assembly
comprising these sub-systems. One method
of defining the dynamic characteristics of
the sub-system is to specify its immittance
matrix. It is therefore desirable to obtain a
mathematical model of a component that is
capable of generating this immittance ma-
trix. Such a model can be obtained from
experimental data produced from a vibration
test on the component and the process of
extracting the model from this data is
termed immittance identification. This
paper shows how such modeling was per-
formed. Components comprising a vehicle
suspension were considered.

85-1817
**Investigations into the Dynamics Behavior
of a Pusher-Type Articulated Bus (Fahr-
dynamische Untersuchungen an einem
Schubgelenkbus)**
H. Bruns, G. Matyssek, G. Stangl
Automobiltech. Z., 86 (12), pp 551-554 (Dec
1984), 8 figs (In German)

Due to the controversy surrounding the
vehicle dynamics of pusher-type articulated
buses, thorough investigations were neces-
sary. Kassbohrer developed an articulated
unit for dynamic testing. This pusher was
equipped with a "Schenk" type coupling. A
brake integrated into the coupling provides
full control of the relative horizontal move-
ments of the two bus bodies. Critical driv-
ing situations were simulated at critical
speeds, in particular: accelerating, swerving
and braking on low-friction surfaces and
especially swerving at high speeds. All
these critical conditions can be controlled
through correct application of the brake in

the coupling. Thus the brake seems to
have made articulated busses suitable for a
wide range of operating conditions.

85-1818
**Numerical Simulation of Dynamic No-Load
Behaviour of Passenger Car Transmission
(Numerische Simulation des dynamischen
Leerlaufverhaltens von Pkw-Getrieben)**
M. Weck, S. Lachenmaier, H. Salje
VDI-Z, 126 (18), pp 663-666 (1984), 3 figs,
1 table, 3 refs (In German)

The low idling speeds imposed on passenger
car engines for economical and environ-
mental reasons lead to excessive speed
fluctuations. These in their turn result in
additional dynamic excitation within the
subsequent power train system, manifested
through "idle gear rattle" in the transmis-
sion. These additional excitations can be
attenuated with the aid of special absorb-
ing-type suspension systems, provided that
optimal matching can be achieved. With
the aid of numerical simulation programs it
is possible to reproduce the complex vibra-
tion behavior of the structures involved,
whereby the calculated variation of forces
may serve as assessment function for the
possible design of the suspension systems in
question.

85-1819
**Influence of Car Body Constructive Pa-
rameters on Acoustic Characteristics of
Car Cavity**
M. Kojic, Z. Petronijevic, V. Manojlovic
Zavodi Crvena Zastava', 34000 Kragujevac,
Yugoslavia
Intl. J. Vehicle Des., 5 (6), pp 704-720 (Nov
1984), 20 figs, 4 tables, 9 refs

Some basic equations for the acoustic
modal analysis of a car cavity, based on

the finite element method are presented. Also equations for the acoustic pressure determination in the case of vibrations of car body parts are derived. A computer program is developed and applied to the analysis of the automobile 'Zastava 101.' From the results obtained, conclusions are drawn about the influence of some changes of the car body geometry on acoustic characteristics, as well as those corresponding to the pressure distribution due to the vibrations of the roof, floor, front and rear windows.

All different types of loss of stability which occur generically for a tractor semitrailer vehicle are studied when varying two parameters namely the speed of the vehicle and the position d of the center of mass of the trailer. This paper furthermore indicates how a nonlinear investigation of stability problems in vehicle dynamics with no restriction to the number of degrees of freedom of the system can be done in a straight forward manner.

This paper reviews the application of the finite element method to acoustic design of the automobile passenger compartment. Low-frequency noise in the passenger compartment is of primary interest, and particularly that noise which is generated by the structural vibration of the wall panels of the compartment. The paper describes the finite element methodology for analyzing the passenger compartment acoustics to diagnose and reduce this noise.

To evaluate farm field profiles as sources of tractor vibration, profiles of meadows and rough terrains were measured and analyzed.

Off-road vehicles, wheeled or tracked, such as commercial vehicles or military vehicles, have to operate under extreme terrain conditions. One aspect of these conditions is the terrain roughness, which has an

important influence, on the one hand on the vehicle stress, on the cargo or attached implements, and on the other hand on the ride comfort for the driver. Therefore, the need for reducing the shock and vibration levels, taking into account increasing travel speed, becomes an important criterion for the design of most of the above vehicles.

niques involving the use of impulse tests have been used in this study to estimate track stiffness and track damping, on several different track structures on the Indian Railways. The results of these tests are presented.

85-1824

Dynamic Simulation of Track Laying Vehicles

M.D. Bennett, P.H.G. Penny
Royal Military College of Science, Shrivenham, UK
Proc. of Intl. Conf. on Performance of Off-Road Vehicles and Machines (8th), Vol. 1, Cambridge, England, Aug 5-11, 1984, pp 153-170, AD-P004 266/3/GAR

KEY WORDS: Tracked vehicles, Computerized simulation

A computer model to simulate the dynamic response of a track laying vehicle traversing defined terrain is described. Results used for validation tests are given together with a selection of typical applications. The model has proved to be flexible with applicability to a wide range of problems.

85-1825

Evaluation of Track Stiffness and Track Damping

V.V. Singh, D. Deepak
Research Designs and Standards Organization, Lucknow 226011, India
J. Sound Vib., 97 (1), pp 129-135 (Nov 8, 1984), 2 figs, 2 tables, 9 refs

KEY WORDS: Railroad tracks, Stiffness coefficients, Damping coefficients

Correct estimation of track stiffness and track damping is essential for predicting the dynamic wheel loads of railway vehicles running on rough tracks. While several analytical procedures have been developed in the past to estimate track stiffness, there is no procedure readily available for estimating track damping. Experimental tech-

85-1826

Dynamic Interaction Between Track and Soil

P. Parringer
Industrieanlagen-Betriebsgesellschaft m.b.H., Ottobrunn, Fed. Rep. Germany
Proc. of Intl. Conf. on Performance of Off-Road Vehicles and Machines (8th), Vol. 1, Cambridge, England, Aug 5-11, 1984, pp 329-347, AD-P004 274/7/GAR

KEY WORDS: Tracked vehicles, Solid-structure interaction, Measurement techniques

The knowledge of the dynamic interaction between track and soil is important to analyze high speed vehicles with flexible track. This paper describes a possible method for the measurement of this interaction. Force-and displacement-sensors are fixed in and on the track to measure longitudinal, transversal- and normal-load at one track-shoe, sinkage of this track-shoe and the longitudinal- and transversal slip of this track shoe.

85-1827

Analysis of Rail Transit Vehicle Dynamic Curving Performance

D.N. Wormley, J.K. Hedrick, M.L. Nagurka
Massachusetts Inst. of Tech., Cambridge, MA
Rept. No. UMTA-MA-6-25-84-1, DOT-TSC-UMTA-84-6, 230 pp (June 1984), PB85-112845/GAR

KEY WORDS: Railroad trains, Cornering effects

Computer simulation models have been developed to analyze the stability and curving performance of transit vehicles with conventional, radial and forced-steered trucks. Analytical tools were used to generate extensive parametric data characteriz-

ing the steady-state curving stability performance tradeoffs offered by various truck and wheel profile designs. The steady-state curving analysis has been extended to develop a dynamic curving model for computing the time varying wheel-rail interaction forces and vehicle suspension and body forces and motions during curve entry and exit. The dynamic curving model includes nonlinear wheel/rail geometry, including multi-point wheel-rail contact, nonlinear vehicle suspension elements, and rail lateral flexibility.

For the future high speed transportation systems a dynamic qualification of the vehicle is needed, so that the motion of wheel sets at high speeds could be controlled. For the interpretation of ride dynamics (sinusoidal motion, cornering) and vibration (ride comfort) an exact knowledge of the dynamic behavior of the entire system is indispensible. For the calculation of wheel-road interaction a program MEDUSA was developed. This program contains a linear multibody formulation for rigid and elastic bodies. The data for the elastic bodies can be obtained by means of an FE formulation and modal transformation,or it can be measured.

85-1828
Wheel/Rail Contact: Geometrical Study
E. Garcia-Vadillo, J.G Gimenez, J.A. Tarrago
Escuela Superior de Ingenieros Industriales. Alameda de Urquijo s/n. 48013 Bilbao
Vehicle Syst. Dynam., 13 (4), pp 207-214 (1984), 5 figs, 15 refs

KEY WORDS: Rail-wheel interaction

Before trying to ascertain the precise nature of the wheel-rail contact the geometrical problem must necessarily be solved. That is, for each position of the wheelset the two dependent parameters and the coordinates of the points of contact of each wheel, and rail must be obtained. A new method is proposed of obtaining the spatial position of a wheelset with reference to the rails, from the most general point of view.

85-1829
Simulation Model of a Freight Car for a Multibody System Formulation from a Finite Element Model and Stationary Vibration Tests
B. Fischer, P. Conrad, H. Bauer
Dynamische Probleme. Modellierung and Wirklichkeit. Proc. mtg. Oct 4-5, 1984, Hannover, Curt-Risch-Institut der Universitat Hannover, Hannover, Fed. Rep. Germany, Vol. I, pp 69-138, 22 figs, 1 table, 6 refs (In German)

KEY WORDS: High speed transportation systems, Railroad cards, Simulation, Computer programs

85-1830
Influence of Wheel-Rail Profiles on the Hunting Vibrations of Rail Vehicle Trucks
A.F. D'Souza, W.J. Tsung
Illinois Inst. of Technology, Chicago, IL 60616
J. Vib., Acoust., Stress, Rel. Des., Trans. ASME, 107 (2), pp 167-174 (Apr 1985), 12 figs, 2 tables, 12 refs

KEY WORDS: Railroad cars, Rail-wheel interaction, Hunting motion

The effect of several wheel and rail profiles on the hunting behavior of three-piece North American freight truck is investigated by the method of describing functions. It is shown that the wearing of the rail profile has a significant adverse effect on the dynamic behavior. It greatly lowers the critical speed for the onset of hunting and raises the frequency, thereby causing high acceleration levels. It is also shown that the modified Heumann wheel profile exhibits a superior dynamic performance for freight trucks than the standard new wheel profile used in North America. The effects of wheel wear and loads on hunting are also investigated.

85-1831
Dynamic Design Verification of a Rapid Transit Rail Car
O. Dossing

KEY WORDS: Railroad cars, Modal analysis, Design techniques

This article presents the use of modal analysis to verify the dynamic design of a rail car prototype. The primary purpose of the test was to verify the natural frequency of the first vertical bending mode for the new design. Measurements were made on two prototype cars plus two similar cars of an older type. Based on the modal model, the sensitivity of the first bending mode to an assumed excitation was estimated and compared between the four cars. The change in frequency for the first bending mode due to adding payload (passengers) was then predicted by simulation.

85-1832
Numerical Investigation and Measurement of Rail-Wheel Interaction in Vehicles with High Rail and Wheel Flange Wear (Rechnerische Untersuchung und Messung des Zusammenwirkens von Rad und Schiene an zu starkem Schienenflanken-
O. Krettek, M. Ofierzynski
RWTH Aachen, Fed. Rep. Germany
Dynamische Probleme. Modellierung und Wirklichkeit. Proc. mtg. Oct 4-5, 1984, Hannover, Curt-Risch-Institut der Universität Hannover, Hannover, Fed. Rep. Germany, Vol. I, pp 155-176, 20 figs, 7 refs (In German)

KEY WORDS: Railroad trains, Transportation vehicles, Rail wheel interaction

The construction of rail transportation systems must adhere to strict geometric, kinematic, static and dynamic restrictions. A computer program under development is described which satisfies all four of the above requirements.

85-1833
Identification and Verification of Frequency-Domain Models for XV-15 Tilt-Rotor Aircraft Dynamics
M.B. Tischler, J.G.M. Leung, D.C. Dugan
NASA Ames Res. Ctr., Moffett Field, CA
Rept. No. A-9851, NASA-TM-86009, 20 pp (Aug 1984), N84-34445/GAR

KEY WORDS: Aircraft, Frequency domain method

Frequency-domain methods are used to extract the open-loop dynamics of the XV-15 tilt-rotor aircraft from flight test data for the cruise condition. The frequency responses are numerically fitted with transfer-function forms to identify equivalent model characteristics.

85-1834
Theoretical Design of Acoustic Treatment for Noise Control in a Turboprop Aircraft
R. Vaicaitis, J.S. Mixson
Columbia Univ., New York, NY
J. Aircraft, 22 (4), pp 318-324 (Apr 1985), 9 figs, 1 table, 29 refs

KEY WORDS: Aircraft, Noise reduction

An analytical procedure has been developed for design of acoustic treatment for cabin noise control of light aircraft. Using this approach acoustic add-on treatments capable of reducing the average noise levels in the cabin by about 17 dB from the untreated condition are developed. The added weight of the noise control package is about 2% of the total gross takeoff weight of the aircraft. The analytical model uses modal solutions wherein the structural modes of the sidewall and the acoustic modes of the receiving space are accounted for. The input noise spectral levels are selected utilizing experimental flight data. The add-on treatments include aluminum honeycomb panels, constrained layer damping tape, porous acoustic materials, noise barriers, limp trim panels, and tuned dampers. To reduce the noise transmitted through the

double-wall aircraft windows to acceptable levels, changes in the design of the aircraft window are recommended.

deg leading-edge sweep angles. The purpose of the study was to evaluate the effects of fuselage incidence on wing performance and to determine the ability of two linearized theory aerodynamic methods to predict these effects.

85-1835
Supersonic Jet Shock Noise Reduction
J.R. Stone
NASA Lewis Res. Ctr., Cleveland, OH
Rept. No. E-2299, NASA-TM-83799, N84-35085/9/GAR

KEY WORDS: Supersonic aircraft, Noise reduction

Shock-cell noise is identified to be a potentially significant problem for advanced supersonic aircraft at takeoff. Therefore NASA conducted fundamental studies of the phenomena involved and model-scale experiments aimed at developing means of noise reduction. The results of a series of studies conducted to determine means by which supersonic jet shock noise can be reduced to acceptable levels for advanced supersonic cruise aircraft are reviewed.

85-1836
Impact of Fuselage Incidence on the Supersonic Aerodynamics of Two Fighter Configurations
R.M. Wood, D.S. Miller
NASA Langley Res. Ctr., Hampton, VA
J. Aircraft, 22 (5), pp 423-428 (May 1985), 15 figs, 11 refs

KEY WORDS: Supersonic aircraft, Aerodynamic loads

An experimental and theoretical investigation of fuselage-incidence effects on two fighter aircraft models, which differed in wing planform shape only, has been conducted in Plan Wind Tunnel at Mach numbers 1.6, 1.8, and 2.0. Experimental and theoretical results were obtained on the two models with fuselage-incidence angles of 0, 2, and 5 deg. The fuselage geometry consisted of two side-mounted, flow-through, half-axisymmetric inlets and twin vertical tails. The two planforms tested were advanced cranked wings of 70/66 and 70/30

85-1837
Dynamics of Forebody Flow Separation and Associated Vortices
L.E. Ericsson, J.P. Reding
Lockheed Missiles and Space Co., Inc., Sunnyvale, CA
J. Aircraft, 22 (4), pp 329-335 (Apr 1985), 18 figs, 28 refs

KEY WORDS: Aircraft, Aerodynamic loads, Vortex shedding

It is well established that there is a strong coupling between body motion and boundary layer separation with attendant vortex shedding. In the present paper this coupling is studied for the particular case of a missile or an aircraft fuselage at very high angles of attack. It is shown that the unusual results obtained in recent tests can be explained by considering the so-called "moving-wall effect" on boundary layer transition and/or separation.

85-1838
Application of Advanced Parameter Identification Methods for Flight Flutter Data Analysis with Comparisons to Current Techniques
H.J. Perangelo, P.R. Waisanen
Grumman Aerospace Corp., Calverton, NY
29 pp (July 1984)(Proc. Flight Mechanics Panel Symp., Lisbon, Portugal, Apr 2-5, 1984, pp 5-1 - 5-29), AD-P004 102

KEY WORDS: Aircraft, Flutter, Parameter identification technique

Grumman has been pursuing the implementation and evaluation of advanced parameter identification software for use in flutter test data processing operations as its Automated Telemetry Station. They have been motivated by aircraft design tending toward

thin, lightweight aircraft structures, which make it difficult to use authoritative shaker systems, and the continuing development of high-speed digital computer technology. This development activity is aimed at establishing an on-line processing capability, in the 1985 time frame that will initially use the maximum likelihood parameter identification algorithm in conjunction with a detailed physical aeroelastic aircraft model to perform optimal flutter test data analysis.

A method for the active vibration suppression of a cantilever wing is presented. The approach is based on modal control, in which a modal feedback control law relating the motion of the control surfaces to the controlled modes is implemented. Modal displacements and velocities required for feedback are extracted from sensor measurements by means of modal filters. A numerical example is presented.

Design of a Flutter Suppression System for an Experimental Drone Aircraft

J.R. Newsom, A.S. Pototzky, I. Abel
NASA Langley Res. Ctr., Hampton, VA

KEY WORDS: Aircraft, Remote control, Active flutter control

This paper describes the design of a flutter suppression system for a remotely-piloted research vehicle. The modeling of the aeroelastic system, the methodology used to synthesize the control law, the analytical results used to evaluate the control law performance, and ground testing of the flutter suppression system onboard the aircraft are discussed. The major emphasis is on the use of optimal control techniques employed during the synthesis of the control law.

Active Vibration Suppression of a Cantilever Wing

L. Meirovitch, L.M. Silverberg
Virginia Polytechnic Inst. and State Univ.,
Blacksburg, VA

KEY WORDS: Cantilever beams, Aircraft wings, Active vibration control, Modal control technique

Measured and Calculated Airloads on a Transport Wing Model

W.E. McCain
NASA Langley Res. Ctr., Hampton, VA

KEY WORDS: Aircraft wings, Aerodynamic loads

Wind tunnel measurements of steady and unsteady pressures for a high-aspect-ratio supercritical wing model are compared with calculations by the linear unsteady aerodynamic lifting-surface theory, known as the doublet lattice method, at Mach number of 0.60 (subsonic) and 0.78 (transonic). The steady-pressure data comparisons are made for incremental changes in angle of attack and control-surface deflection. The unsteady-pressure data comparisons are made for oscillating control-surface deflections. Some differences between the measured and calculated aerodynamics are attributed to viscous and transonic effects not accounted for in the doublet lattice analysis. Comparisons of the transonic unsteady-pressure data for the oscillating control surfaces are improved by applying empirical corrections, based on the steady-pressure measurements, to the unsteady doublet lattice calculations.

Aerodynamic Canard/Wing Parametric Analysis for General Aviation

M.W. Keith, B.P. Selberg
Univ. of Missouri, Rolla, MO

KEY WORDS: Aircraft Wings, Aerodynamic Loads

Vortex panel and vortex lattice methods have been utilized in an analytic study to determine the two-and three-dimensional aerodynamic behavior of canard/wing configurations. The purpose was to generate data useful for the design of general-aviation canard aircraft. Moderate two-dimensional coupling was encountered and the vertical distance between the lifting surfaces was found to be the main contributor to interference effects of the three-dimensional analysis. All canard configurations were less efficient than a forward wing with an aft horizontal tail, but were less sensitive to off-optimum division of total lift between the two surfaces, such that trim drag could be less for canard configurations. For designing a general-aviation canard aircraft, results point toward large horizontal and vertical distances between the canard and wing, a large wing-to-canard area ratio, and the canard at a low-incidence angle relative to the wing.

85-1843
Ground Vibration Test of F-16 Airplane with Initial Decoupler Pylon
F.W. Cazier, M.W. Kehoe
NASA Langley Res. Ctr., Hampton, VA
Rept. No. NASA-TM-86259, 47 pp (Oct 1984) N84-34439/GAR

KEY WORDS: Aircraft, Wing stores, Active flutter control

A ground vibration test was conducted on an F-16 airplane loaded on each wing with a 370-gal tank mounted on a standard pylon, a GBU-8 store mounted on a decoupler pylon, and an AIM-9J missile mounted on a wing-tip launcher. The decoupler pylon is a passive wing/store flutter-suppression device. The test was conducted prior to initial flight tests to determine the modal frequencies, mode shapes, and structural damping coefficients. The data presented include frequency plots, force effect plots, and limited mode shape data.

85-1844
Noise Transmission Through Aircraft Panels
R. Vaicaitis, F.W. Grosveld, J.S. Mixson
Columbia Univ., New York, NY
J. Aircraft, 22 (4), pp 303-310 (Apr 1985) 9 figs, 47 refs

KEY WORDS: Aircraft, Panels, Noise Transmission, Structural members

This paper describes analytical and experimental studies of noise transmission through aircraft panels. The theoretical solutions of the governing acoustic-structural equations are developed utilizing modal decomposition and a Galerkin-type procedure. Single, discretely stiffened, and double wall panels are considered. Theoretical predictions are compared with experimental measurements.

85-1845
Noise Transmission Through an Acoustically Treated and Honeycomb-Stiffened Aircraft Sidewall
F.W. Grosveld, J.S. Mixson
The Bionetics Corp., Hampton, VA
J. Aircraft, 22 (5), pp 434-440 (May 1985) 14 figs, 18 refs

KEY WORDS: Aircraft, Honeycomb structures, Noise transmission, Structural members

The noise transmission characteristics of test panels and acoustic treatments representative of an aircraft sidewall are experimentally investigated in the NASA Langley Research Center transmission loss apparatus. The test panels were built to represent a segment of sidewall in the propeller plane of a twin-engine, turboprop light aircraft. It is shown that an advanced treatment, which uses honeycomb for structural stiffening of skin panels, has better noise transmission loss characteristics than a conventional treatment. An alternative treatment for the same total surface mass. Effects on transmission loss of a variety of acoustic treatment materials (acoustic blankets, septa, damping tape, and trim panels) are presented. Damping tape does not provide additional benefit when the other treatment provides a high level of damping.

Window units representative of aircraft installations are shown to have low transmission loss relative to a completely treated sidewall.

A 1/7-scale research model of the AH-1 series helicopter main rotor was tested in the open-jet anechoic test section. Model-rotor acoustic data were recorded at high forward speeds where full-scale helicopter high-speed impulsive noise levels are known to be dominant. Model-rotor measurements of the peak acoustic pressure levels, waveform shapes, and directivity patterns are directly compared with full-scale investigations, using an equivalent in-flight technique. Model data are shown to scale remarkably well in shape and amplitude with full-scale results. Parametric variations of the model-rotor acoustic measurements are also presented.

Air resonance with dynamic inflow is studied in forward flight. Effects of trimming conditions and parameters such as lag structural damping, blade and body inertias and aeroelastic couplings are included. The stability margin of the lag regressing mode in the hovering could worsen in forward flight, particularly for the soft inplane rotors in propulsive trim and for the stiff inplane rotors in moment or wind-tunnel trim.

The present paper deals with the investigation on helicopter main rotor noise performed at ONERA. Theoretical results, already published, are only summarized. An overview of the experimental scopes is also given. The joint program with the U.S. Army is emphasized: measurements in CEPRA 19 anechoic wind tunnel are described. The comparison with U.S. Army inflight data validates the similitude rules on scaled models; finally the computation of thickness noise shows a good agreement with experimental results.

Active control of rotor-induced vibration in rotorcraft has received significant attention

recently. Two classes of techniques have been proposed. The more developed approach works with harmonic analysis of measured time histories and is called the frequency-domain approach. The more recent approach computes the control input directly using the measured time history data and is called the time-domain approach. The report summarizes the results of a theoretical investigation to compare the two approaches.

This report documents the results of a Federal Aviation Administration noise measurement flight test program with the Boeing-Vertol CH-47D helicopter. The report contains documentary sections describing the acoustical characteristics of the subject helicopter and provides analyses and discussions addressing topics ranging from acoustical propagation to environmental impact of helicopter noise.

85-1850
A Description of Helix and Felix, Standard Fatigue Loading Sequences for Helicopters, and of Related Fatigue Tests Used to Assess Them

P.R. Edwards
Royal Aircraft Establishment, Farnborough, Happen, England

Helix and Felix are standard loading sequences which relate to the main rotors of helicopters with articulated and semi-rigid rotors respectively. The purpose of the loading standards is, first, to provide a convenient tool for providing fatigue data under realistic loading, which can immediately be compared with data obtained by other organizations. Second, loading standards can be used to provide design data. This paper outlines the form of Helix and Felix, summarizes their statistical content according to different counting methods and gives results of fatigue tests used to assess their usefulness.

85-1852
Noise Measurement Flight Test: Data/Analyses, Hughes 500 D/E Helicopter

J.S. Newman, E.J. Rickley, T.L. Bland, K.R. Beattie
Federal Aviation Admn., Washington, D.C.

The report contains documentary sections describing the acoustical characteristics of the subject helicopter and provides analyses and discussions addressing topics ranging from acoustical propagation to environmental impact of helicopter noise. This report is the third in a series of seven documenting the FAA helicopter noise measurement program conducted at Dulles International Airport during the summer of 1983. The Hughes 500D/E test program involved the acquisition of detailed acoustical, position and meteorological data.

MISSILES AND SPACECRAFT

85-1851
Noise Measurement Flight Test for Boeing Vertol 234/CH 47-D Helicopter: Data/Analyses

J.S. Newman, T.L. Bland, K.R. Beattie
Federation Aviation Admn., Washington, D.C.

85-1853
Analytical Model of Pulsing of Solid Propellant Rocket Motors

R.M. Hackett, C.E. DeVilbiss
The Univ. of Alabama in Huntsville, Huntsville, AL

KEY WORDS: Solid propellant rocket engines, Finite element technique, Modal superposition methods, Acoustical pulses

The finite-element formulations of structural and acoustical free-vibration problems are reviewed and compared, and the mode superposition analysis technique is presented. A direct analogy is developed between the application of mode superposition to combustion instability analysis, and its proven application in structural analysis. A computer program which models the response of pulsed solid propellant rocket motor cavities is presented, and examples that demonstrate the application of the program are discussed.

85-1854
Vibration, Acoustic, and Shock Design and Test Criteria for Components on the Solid Rocket Boosters (Srb), Lightweight External Tank (Lwt), and Space Shuttle Main Engines (Ssme).
NASA George C. Marshall Space Flight Ctr., Huntsville, AL
Rept. No. NASA-RP-1127, 812 pp (Sept 1984) N85-10405 /7/GAR

KEY WORDS: Spacecraft components

The vibration, acoustics, and shock design and test criteria for components and subassemblies on the space shuttle solid rocket booster lightweight tank and main engines are presented. Specifications for transportation, handling, and acceptance are also provided.

85-1855
Damping Synthesis for a Spacecraft Using Substructure and Component Data
K.W. Lips, F.R. Vigeron
Communications Res. Centre, Ottawa, Ontario, Canada
Rept. No. CRC-1365, 88 pp (Aug 1984) N85-12082 /2/GAR

KEY WORDS: Spacecraft, Modal synthesis, Modal damping, Substructuring methods, Component mode analysis

A method for the synthesis of modal damping factors and other modal data for a spacecraft in orbit is demonstrated It is based on input information at the component/substructure level. Also, the use of the method and the level of accuracy obtained is illustrated in a case study of the Hermes spacecraft. The synthesis procedure is demonstrated for a spacecraft configuration consisting of a central rigid body, solar array substructures, a momentum wheel and a liquid mercury damping device.

85-1856
Dynamic Response of the LE-5 Rocket Engine Liquid Oxygen Pump
T. Shimura, K. Kamijo
National Aerospace Lab. of Japan, Miyagi, Japan
J. Spacecraft, 22 (2), pp 195-200 (Mar/Apr 1985) 14 figs, 4 tables, 14 refs

KEY WORDS: Pumps, Liquid propellant rocket engines, POGO effect

A three stage H-1 rocket has been developed, the second stage of which has a LOX/LH$_2$ engine. LE-5. Regarding the POGO phenomenon of the second stage of the H-1 rocket, analyses are being conducted in order to determine whether or not a POGO suppression device is necessary for the LE-5 engine. In this study, the dynamic characteristics of the liquid oxygen pump of the LE-5 engine were examined by artificially creating periodical perturbations in the pump flow in order to obtain the data necessary for POGO analysis of the H-1 rocket.

BIOLOGICAL SYSTEMS

HUMAN

85-1857
Further Development in Ride Quality Assessment
N.R. Murphy, Jr.

Army Engineer Waterways Experiment Station, Vicksburg, MS
(Proc. of Intl. Conf. on Performance of Off-Road Vehicles and Machines (8th), Vol. 1, Cambridge, England, Aug 5-11, 1984, pp 433-449) AD-P004 280/4/GAR

KEY WORDS: Human response, Vibration excitation, Ground vehicles

Internationally, a growing concern has developed and widespread disagreement has occurred over the present methods for quantitatively describing and assessing the effects of vehicle vibrations on humans, and over the short-and the long-term effects of vibrations on drivers and occupants of heavy trucks, agricultural and earthmoving equipment, and military vehicles. None of the present methods is completely satisfactory; in fact, most criteria were developed for low-level boulevard rides and are highly suspect when applied to the several vibrational levels conducted in earthmoving and military-type operations.

85-1859
Simulation of Human Body Dynamic Response to Crash Loads
D.H. Robbins, D. Simic
Univ. of Michigan, Ann Arbor, MI 48109
Intl. J. Vehicles Des., 6 (2), pp 216-227 (Mar 1985) 11 figs, 40 refs

KEY WORDS: Human response, Collision research (automotive)

A review of the development of several crash victim simulation models. Applications of these models to various automotive safety problems are described based on the work of a number users both in the United States and Europe. It is concluded that crash victim simulation models can serve the automobile designer as a tool to reduce test costs when combined with well-conceived laboratory test programs.

MECHANICAL COMPONENTS

ABSORBERS AND ISOLATORS

85-1858
Ride Comfort of Off-Road Vehicles
G.H. Hohl
Austrian Federal Army, Vienna
Proc. of Intl. Conf. on Performance of Off-Road Vehicles and Machines (8th), Vol. 1, Cambridge, England, Aug 5-11, 1984, pp 413-432 AD-P004 279/6/GAR

KEY WORDS: Off-highway Vehicles, Human response

Because of the roughness of the terrain they encounter, cross country vehicles experience more shock and vibration than ordinary road vehicles. Hence off-road speed is usually limited by the ability of the operator to withstand these vibrations to negotiate and to retain adequate, control of the vehicle. In addition to the other factors, the comfort of the operator, which contributes to his general safety, also depends on the physical characteristics of the seat, which is the link between the driver and the vehicle.

85-1860
Dynamic Testing of Glass-Fibre Reinforced Plastics for the Design of Bumper Systems
K.D. Johnke, H. Fehrecke
Volkswagenwerk AG - Wolfsburg, Fed. Rep. Germany
Intl. J. Vehicle Des., 6 (2), pp 199-215 (Mar 1985) 13 figs, 6 tables, 14 refs

KEY WORDS: Bumpers, Glass-reinforced plastics, Dynamic tests

The extent to which lightweight construction can realistically be applied to bumper systems by using composite materials and the question as to whether or not these high polymers can make it possible to save enough energy to meet economic requirements are discussed here. In addition, the findings, arising from the determination of deformation-related degrees of damage to glass-fibre reinforced plastics and their possible influence on the design of new bumper systems are discussed. Examples

show how glass-fibre reinforced and glass-fibre mineral reinforced high-polymers, both compact and foamed, can be used effectively.

Mitsubishi Denki Giho, 58 (1), pp 20-25 (1984) PB85-136042/GAR (In Japanese)

Mitsubishi Electric has developed, in cooperation with Mitsubishi Motors Corporation, an electronically controlled suspension (ECS) system that well satisfies the demands for both a comfortable ride and drive stability. One important features of this ECS is its combination of the vehicle-height control function with the functions for selecting spring constants and damping force, and the high reliability of its sensors, actuators and control unit. The article includes descriptions of the system configuration and its functions.

85-1861
Strain-Rate and Inertia Effects in the Collapse of Two types of Energy-Absorbing Structure

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The dynamic plastic collapse of energy-absorbing structures is more difficult to understand than the corresponding quasi-static collapse, on account of two effects which may be described as the "strain-rate factor" and the "inertia factor," respectively. The first of these is a material property whereby the yield stress is raised, while the second can affect the collapse mode, etc. It has recently been discovered that structures whose load-deflection curve falls sharply after an initial "peak" are much more "velocity sensitive" than structures whose load-deflection curve is "flat-topped." In this paper we investigate strain-rate and inertia effects in these two types of structure by means of some simple experiments performed in a drop hammer testing machine together with some simple analysis which enables us to give a satisfactory account of the experimental observations. The work is motivated partly by difficulties which occur in small-scale model testing of energy-absorbing structures, on account of the fact that the strain-rate and inertia factors not only scale differently in general, but also affect the two distinct types of structure differently.

85-1863
Synthesis of Dynamic Vibration Absorbers

B.P. Wang, L. Kitis, W.D. Pilkey, A. Palazzolo
Univ. of Texas at Arlington, Arlington, TX 76019

A method for designing dynamic vibration absorbers which create antiresonances at specified points on a sinusoidally forced vibratory system is described. Spring-mass absorber systems are treated in detail. Among all possible solutions, a unique minimum mass solution is shown to exist if the relative displacement of the absorber mass is constrained. The sensitivity of the design to variations in frequency, spring constant, and absorber mass is discussed. The procedure is illustrated by numerical results for a simply supported uniform beam.

85-1862
Electronically Controlled Suspension System

S. Wada, M. Hirata
Mitsubishi Electric Corp., Tokyo, Japan

85-1864
Pneumatic Actuators for Vehicle Active Suspension Applications

D. Cho, J.K. Hedrick

Massachusetts Inst. of Tech., Cambridge, MA
02139
J. Dynam. Syst., Meas. Control, Trans.
ASME, 107 (1), pp 67-72 (Mar 1985) 11
figs, 2 tables, 13 refs

KEY WORDS: Suspension systems (vehicles),
Actuators, Active control, Railroad trains

The use of actively controlled pneumatic
actuators in parallel with conventional pas-
sive suspensions to improve vehicle dynam-
ics was investigated. For application on the
secondary lateral suspension of AMTRACK
passenger cars, it is shown that using 4 in.
bore pneumatic cylinders with a valve
which has a peak flow capability of 40
SCFM at 130 psi can reduce the rms car-
body lateral acceleration by 46 percent
and the rms secondary lateral suspension
stroke by 34 percent with a power require-
ment of 7.6 hp per car.

85-1865
An Active Suspension for a Formula One
Grand Prix Racing Car
J. Dominy, D.N. Bulman
Rolls-Royce Ltd., Transmissions Research
Group, Aero Div., Derby, UK
J. Dynam. Syst., Meas. Control, Trans.
ASME, 107 (1), pp 73-78 (Mar 1985) 12
figs, 6 refs

KEY WORDS: Suspension systems (vehicles),
Active control, Automobiles

During 1982, Formula 1 racing cars gener-
ated very high downforces by the use of
"ground effect" aerodynamics. Such cars
required very stiff suspensions to maintain a
reasonably constant ride height with the
result that the slightest bump unsettled the
chassis and reduced cornering speeds. A
semi-active suspension would have been
capable of withstanding the variations in
downforce while remaining "soft" to rapid
road inputs. This paper proposes such a
system and describes an analysis of its
dynamic responses.

85-1866
A New Rear Axle Suspension for M.A.N.
Buses (Neue Hinterachsfuhrung fur M.A.N.-
Omnibusse)
U. Breitling, P. Wypich
Herzogstrasse 59, 8000 Munchen 40
Automobiltech. Z., 86 (12), pp 545-548 (Dec
1984) 6 figs (In German)

KEY WORDS: Suspension systems (vehicles),
Buses, Fatigue life, Finite element technique

A standardized suspension system was to be
developed for the drive axles in M.A.N.'s
various production bus models. An A-frame
design was chosen to provide the required
driving comfort, but modified into an open-
ended unit separable into two parts to fa-
cilitate manufacture and assembly while
reducing weight. Extensive load data were
collected by evaluating vehicle test runs
both at home and abroad. A preliminary
design was determined by FEM computa-
tion. The suspension's fatigue life was
documented using a hydro-power test rig
while vehicle tests were carried out. After
proving its worth in prototype vehicles, the
new A-frame suspension has been intro-
duced into regular production.

85-1867
Vibration Response — Wheel Suspension —
Comfort (Schwingungsverhalten —Radauf-
hangungen — Komfort)
M. Mitschke
Proc. of the 5th Symp. of the Inst. f. Fahr-
zeugtechnik T.V. Braunschweig, June 26-27,
1984 (In German)

KEY WORDS: Suspension systems (vehicles),
Wheels

In the paper the effects of wheel suspension
on the vibration of vehicle riding on an
uneven street is discussed. It is shown that
rigid axles are worse for the wheel during
lateral vibration than good individual wheel
suspensions, and that a compromise between
comfort and safety is hard to find.

Railway Wheel Squeal (3rd Report, Squeal of a Disk Simulating a Wheel in Internal Resonances)
M. Nakai, M. Yokoi
Kyoto Univ., Yoshida-honmachi, Sakyo-ku, Kyoto, Japan

KEY WORDS: Railway wheels, Squeal, Disks

We made an apparatus with a steel rod and a thin steel disk. A disk serving as a railway wheel was clamped at inner radius and was free at its end. When a certain relationship exists among the natural frequencies in the axial direction of the disk, various internal resonances occur. We analyzed a squeal of the disk in internal resonances theoretically.

Operating Mode: Measurement of Tire/-Road Contact Noise (Mode Operatoire: Mesure du Bruit de Contact Pneu/Route)
Centre de Recherches Routieres, Brussels, Belgium

KEY WORDS: Tire-pavement interaction, Noise generation, Measurement techniques

A mode of operation is described for measuring the noise level due to tire/road contact of a rolling vehicle in free deceleration, with the engine turned off. The first section deals with measuring the level of maximum noise emitted outside of the vehicle passing in front of a stationary microphone. Part Two concerns measurement of the average noise level prevailing within the (inhabited) vehicle.

Aeroelastic Stability of an Elastic Circulation Control Rotor Blade in Hover
I. Chopra
Univ. of Maryland, College Park, MD 20742

KEY WORDS: Propeller blades, Helicopters, Aeroelasticity, Aerodynamic loads

The aeroelastic stability of flap bending, lead-lag bending, and torsion of a circulation control rotor blade in hover is investigated using a finite element formulation based on Hamilton's principle. Quasisteady strip theory is used to evaluate the aerodynamic forces, and the airfoil characteristics are represented either in the form of simple analytical expressions or in the form of data tables. The blade is discretized into beam elements, each with fifteen nodal degrees of freedom. The nonlinear equations of motion are solved for steady blade deflections through an iterative procedure. The flutter solution is calculated assuming blade motions to be small perturbations about the steady solution. The normal mode method, based on the coupled rotating natural modes about the steady deflections, is used to reduce the number of equations in the flutter eigenanalysis. The effects of several parameters on blade stability are examined, including thrust level, collective pitch, nature of blowing distribution, lag frequency, torsion frequency, and structural damping, and Theodorsen lift deficiency function.

A New Look at Sound Generation by Blade/Vortex Interaction
J.C. Hardin, J.P. Mason
NASA Langley Res. Ctr., Hampton, VA 23665

KEY WORDS: Blades, Vortex-induced vibration, Sound generation

As a preliminary attempt to understand the dynamics of blade/vortex interaction, the two-dimensional problem of a rectilinear vortex filament interacting with a Joukowski airfoil is analyzed in both the lifting and nonlifting cases. The vortex velocity components could be obtained analytically and integrated to determine the vortex trajectory. With this information, the aeroacoustic low-frequency Green's function approach could then be employed to calculate the sound produced during the encounter. The results indicate that the vortex path deviates considerably from simple convection due to the presence of the airfoil and that a reasonably sharp sound pulse is radiated during the interaction whose fundamental frequency is critically dependent upon whether the vortex passes above or below the airfoil. Determination of this gross parameter of the interaction is shown to be highly nonlinearly dependent upon airfoil circulation, vortex circulation, and initial position.

85-1872

A Pitch Control System for the KaMeWa Wind Turbine

B.S. Liebst
Univ. of Minnesota, Minneapolis, MN 55455
J. Dynam. Syst., Meas. Control, Trans. ASME, 107 (1), pp 47-52 (Mar 1985) 6 figs, 2 tables, 7 refs

KEY WORDS: Turbine blades, Wind turbines, Wind-induced excitation, Vibration control

This study is the design of a pitching blade control system for the national Swedish Board for Energy Source Development KaMeWa wind turbine. Full state controllers are designed utilizing optimal control theory to reduce blade and tower vibration, power oscillations, and improve gust response. The results show that substantial vibration reduction can be obtained with the existing pitch actuators installed presently on the machine.

85-1873

Vibrational Power Transmission of an Idealised Gearbox

E.C.N. Leung
Southampton Univ., UK
Rept. No. REPT-124, 96 pp (June 1984)
N85-11346

KEY WORDS: Gear boxes, Journal bearings, Eccentricity, Vibration transfer

The vibrational power transmission of an idealized gearbox or electric motor was analyzed. It is shown that a journal bearing with a high eccentricity ratio has smaller effect on the power transmission process than a journal bearing with a low eccentricity ratio. In the analyses of the point inertances, it was found that the local stiffness at the point of the application force governs the antiresonance. The first resonance of the idealized gearbox configuration is estimated with reasonable accuracy using the result of the point inertance of an infinite plate. The transfer inertance was examined on an aluminum disc. The results agree well with the theoretical predictions.

85-1874

A Finite Element Investigation of a Bearing/Cartridge Interface for a Fretting Corrosion Study

R.J. Stover, H.H. Mabie, M.J. Furey
Virginia Polytechnic Inst. and State Univ., Blacksburg, VA 24061
J. Tribology, Trans. ASME, 107 (2), pp 157-163 (Apr 1985) 11 figs, 16 refs

KEY WORDS: Bearings, Fretting corrosion, Finite element technique

The bearing/cartridge interfaces of a Ship Service Motor Generator Set were modeled by using finite element technology. The purpose of this analytical study was to verify the results of earlier experimental tests made on an actual SSMG unit. This research is part of a larger research project to examine the important parameters influ-

encing the fretting of rolling element bearings.

for the case of a fixed journal axis with a bearing length to diameter ratio of unity. It is concluded that thermal effects are more pronounced for misaligned journal bearings.

85-1875
Effects of Turbulence and Viscosity Variation on the Dynamic Coefficients of Fluid Film Journal Bearings
D.F. Wilcock, O. Pinkus
Tribolock, Inc.
J. Tribology, Trans. ASME, 107 (2), pp 256-261 (Apr 1985) 10 figs, 4 tables, 11 refs

KEY WORDS: Journal bearings, Stiffness coefficients, Damping coefficients, Turbulence, Viscosity effects

Many high-speed or large fluid film bearings operate in the turbulent regime. However, relatively little consideration has been given to the effects of turbulence and of the variation in viscosity on the dynamic stiffness and damping characteristics of the bearings. Since the dynamic behavior of the rotor supported on such bearings is often closely tied to the bearing dynamic coefficients, knowledge of them may be critical to both the design and the in-place correction of rotor instabilities. These effects are here considered in some detail on the basis of computer calculated analytical results, both in general dimensionless terms and with regard to a specific numerical example.

GEARS

85-1877
In-Flight Estimation and Induction of Cumulative Fatigue Damage to Helicopter Gears.
K.F. Fraser
Aeronautical Res. Labs., Melbourne, Australia
Rept. No. ARL-AERO-PROP-REPORT-164, AR-3-13, 113 pp (Mar 1984) N85-12050/GAR

KEY WORDS: Gears, Helicopters, Fatigue life

The safe fatigue life of helicopter transmission components made if in service load data together with transmission fatigue data, represented as the number of cycles of failure as a function of tooth load, were estimated. Instrumentation was developed to provide in flight, estimation and indication of the proportion of safe fatigue life expended for critical gears in single or twin engine helicopter transmission systems.

COUPLINGS

85-1876
An Adiabatic Solution of Misaligned Journal Bearings
M.O.A. Mokhtar, Z.S. Safar, M.A.M. Abd-El-Rahman
Cairo Univ., Cairo, Egypt
J. Tribology, Trans. ASME, 107 (2), pp 263-267 (Apr 1985) 8 figs, 9 refs

KEY WORDS: Journal bearings, Alignment

The paper presents an adiabatic analysis of misaligned journal bearings. The misalignment is allowed to vary in magnitude as well as in direction with respect to the bearing boundaries. Results are obtained

85-1878
Tailoring Drive Output with Elastomeric Couplings
M. Seneczko, ed.
Mach. Des., pp 123-125 (Apr 11, 1985) 6 figs

KEY WORDS: Couplings, Elastomers

Most elastomeric couplings are available with interchangeable flexible members. Thus, besides handling shaft misalignments, couplings can be modified to isolate and damp vibrations, cushion shock, or even provide overload protection. This paper

reviews coupling selection to attendant vibrations and shock.

85-1879
Corrosion Fatigue Tests on Welded Tubular Joints
T. Iwasaki, J.G. Wylde
The Welding Inst., Abington, Cambridge, UK
J. Energy Resources Tech., Trans. ASME,
107 (1), pp 68-73 (Mar 1985) 7 figs, 5 tables, 22 refs

KEY WORDS: Joints, Corrosion fatigue, Fatigue tests

The corrosion fatigue performance of welded tubular joints is recognized as one of the most important factors in the design of offshore structures. Because of the cost of such tests it has been practice to carry out tests on tubular joints in air and to perform corrosion fatigue tests on simple welded joints. The present paper describes the results of fatigue tests which have been carried out on welded tubular joints both in air and in sea water environment.

SEALS

85-1880
An Analysis of "Ringing" Phenomena on a Water Pump Mechanical Seal
K. Kiryu, T. Yanai, S. Matsumoto, T. Koga
Eagle Industry Co., Ltd., Okayama, Japan
ASLE, Trans., 28 (2), pp 261-267 (Apr 1985) 15 figs, 4 tables, 3 refs

KEY WORDS: Seals, Pumps, Sound generation, Stick-slip response

Mechanical seals are used as sealing devices of water pumps in cooling systems of automobile engines. It is observed that water pump seals sometimes generate a "ringing" sound under certain conditions;
however, the mechanisms of "ringing" phenomena have rarely been studied because of the difficulty in reproducing these phenomena. The present investigation is concerned with an experimental and fundamental analysis of "ringing." As a result of observation and discussion of these phenomena, it becomes clear that this "ringing" sound is closely related to the surface condition and the "stick-slip" phenomena of rubbing surfaces of water pump seals.

STRUCTURAL COMPONENTS

STRINGS AND ROPES

85-1881
Vibration of a Bowed String (1st Report — No. 1 Monochord Subject to Air Resistance Only)
S. Maezawa, K. Temma
Meisei Univ., Hodokubo 337, Hino City, Tokyo, 191 Japan
Bull. JSME, 28 (237), pp 475-482 (Mar 1985) 8 figs, 16 refs

KEY WORDS: Strings, Self-excited vibrations

Steady self-excited vibrations of a bowed string, which is perfectly flexible land subject to negative damping due to solid frictional force of general characteristic and to positive damping due to air resistance only, are studied by means of a Fourier series method utilizing series transformation.

CABLES

85-1882
On the Fatigue Strength of Wires in Spiral Ropes
K. Gabriel
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Spiral ropes of high load-bearing capacity are usually made of cold-drawn steel wires of high tensile strength. This material has been investigated by many researchers, not only to determine the mechanical properties of cold-drawn wires, but also to find out more about their stress-strain behavior under tensile loading and local three-dimensional stresses. A method of determining the fatigue strength of tension members made of cold-drawn wires is described using statistical methods, results of fatigue tests on short specimens, and precision measurements of the cold-drawn wire.

BARS AND RODS

85-1883
On a Lower Bound for the Instability Range of Beck's Rod
H.H.E. Leipholz
Univ. of Waterloo, Waterloo, Ontario, Canada N2L 3G1

In this paper, a lower bound for the critical values of a parameter in a boundary eigenvalue problem will be derived. It will provide a safe datum for the design of an unconditionally stable control for the antenna arm.

85-1884
A Global Analysis of a Non-Linear System under Parametric Excitation
R.S. Guttalu, C.S. Hsu
Univ. of California, Berkeley, CA 94720

A strongly nonlinear mechanical system consisting of a rigid damped bar subjected to a periodic parametric excitation is treated in an exact manner. The emphasis is on the global behavior of this system which is carried out by using the point mapping and the cell-to-cell mapping methods. The mechanical system is a simple one, yet it has a very complex global behavior. It is shown that the newly developed theory of cell-to-cell mappings offer a tremendous advantage in obtaining the global domains of attraction of strongly nonlinear dynamical systems.

BEAMS

85-1885
Numerical Analysis of Damped Transient Beam Vibrations by Use of Fourier Transforms
L. Karlsson
Lulea Univ. of Tech., Lulea, Sweden

As an approximation for the mechanism behind noise emission from a rock drilling rod, the transient damped vibrations of a beam (the drilling rod) in bending and shear is studied. At one end the beam is supported by a distributed damped Winkler-type foundation. In order to determine required transfer function from an applied moment at the other end of the beam, it is divided into two finite elements. Each element is treated as a uniform Rayleigh-Timoshenko beam in an ambient medium. The fast Fourier transform technique is utilized.

85-1886
Wave Reflection and Transmission in Beams
B.R. Mace

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KEY WORDS: Beams, Wave reflection, Wave transmission

The vibrational behavior of beam systems can be expressed in terms of waves of both propagating and near field types. A propagating wave incident upon a discontinuity gives rise to reflected and transmitted waves of both kinds whose amplitudes may be found from well-known reflection and transmission coefficients. In this paper the approach is extended to the case of incident near field waves, reflection and transmission matrices being derived for the cases of a point support and a change in section. Reflection at a boundary and the effects of applied excitations are also considered.

85-1887

Non-Linear Free Torsional Vibrations of Thin-Walled Beams with Bisymmetric Cross-Section

B. Rozmarynowski, C. Szymczak
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KEY WORDS: Beams, Torsional vibrations, Finite element technique

A finite element method for studying non-linear free torsional vibrations of thin-walled beams with bisymmetric open cross-section is presented. The nonlinearity of the problem arises from axial loads generated at moderately large amplitude torsional vibrations due to immovability of end supports. The derivation of the fundamental differential equation of the problem is based on the classical assumption of a thin-walled beam with a non-deformable cross-section. The nonlinear eigenvalue problem is solved iteratively by series of linear eigenvalue problems until the required accuracy is obtained.

85-1888

Optimal Design of Thin-Walled I Beams for a Given Natural Frequency of Torsional Vibrations

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KEY WORDS: Beams, Natural frequencies, Torsional vibrations, Axial force, Warping

A method of extremum weight design of thin-walled I beams for a given natural frequency of torsional vibrations is presented. The effects of warping stresses and constant axial loads are taken into account.

85-1889

Vibration of a Beam Due to a Random Stream of Moving Forces with Random Velocity

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Inst. of Civil Engrg., Technical Univ. of Wroclaw, Wroclaw, Poland

KEY WORDS: Beams, Moving loads, Bridges

The problem of dynamic response of a beam to the passage of a train of concentrated forces with random amplitudes and velocities is considered. Force arrivals at the beam are assumed to constitute the point stochastic process of events. Thus, the excitation process is an idealization of vehicular traffic loads on a bridge. An analytical technique is developed to determine the response of the beam. Explicit expressions for the expected value and the variance of the beam deflection are provided.

85-1890

Remote Impact Analysis by Use of Propagated Acceleration Signals, I: Theoretical Methods

G.S. Whiston
Central Electricity Generating Board, Leath-

erhead KT22 7SE, UK
J. Sound Vib., 97 (1), pp 35-51 (Nov 8, 1984) 5 figs, 2 refs

KEY WORDS: Beams, Impact response

A technique for remote impact analysis applicable to on-line vibration wear assessment of installed plant is presented. Beam acceleration transients propagated from impact sites can be spectrally inverted to yield the impact site location and the force time history. The effect of various possible types of signal contamination is analyzed.

85-1891
Remote Impact Analysis by Use of Propagated Acceleration Signals, II: Comparison Between Theory and Experiment
R.W. Jordan, G.S. Whiston
Central Electricity Generating Board, Leatherhead KT22 7SE, UK
J. Sound Vib., 97 (1), pp 53-63 (Nov 8, 1984) 8 figs, 2 refs

KEY WORDS: Beams, Impact response, Timoshenko theory

Techniques for remote impact analysis are analyzed from an experimental point of view. Comparison is made between the theoretical and experimental Timoshenko transfer functions between the remote acceleration transform and the impact force-time history transform. The inversion process has been applied with success to experimental impacting data.

85-1892
Random Vibrations of Elastic Beams and Circular Plates Resting on Viscoelastic Foundations
Y.J. Lin
Hughes Aircraft Co., El Segundo, CA
J. Vib., Acoust., Stress, Rel. Des., Trans. ASME, 107 (2), pp 180-187 (Apr 1985) 5 figs, 6 refs

KEY WORDS: Beams, Circular plates, Random vibration, Viscoelastic foundations

Analytical and numerical results are reported for the dynamic responses of elastic beams and circular plates resting on viscoelastic foundations and excited by stationary, wide-band random forces. Each viscoelastic foundation is treated as a series of an infinite number of many spring-dashpot systems. Three different types of linear viscoelastic models are considered.

85-1893
Vibration Frequencies for a Non-Uniform Beam with End Mass
J.H. Lau
Hewlett-Packard Labs., Palo Alto, CA 94303
J. Sound Vib., 97 (3), pp 513-521 (Dec 8, 1984) 2 figs, 6 tables, 12 refs

KEY WORDS: Cantilever beams, Mass-beam systems, Natural frequencies, Rotatory inertia effects

This study deals with the determination of natural frequencies of a non-uniform cantilever beam which carries a concentrated mass at the free end. The effect of the rotatory inertia of the end mass has been included. Numerical results for the first five eigenfrequencies are presented for a wide range of values of the beam dimensions and the concentrated mass.

85-1894
Nonlinear Vibrations of a Beam with a Mass Subjected to Alternating Electromagnetic Force
H. Kojima, K. Nagaya, H. Shiraishi, A. Yamashita
Gunma Univ., Tenjin-cho, Kiryu, Gunma 376, Japan
Bull. JSME, 28 (237), pp 468-474 (Mar 1985) 6 figs, 1 table, 3 refs

KEY WORDS: Mass-beam systems, Electromagnetic excitation, Superharmonic vibrations, Subharmonic oscillations, Harmonic balance method

The parametric nonlinear forced vibrations of a beam with a mass subjected to alter-

nating electromagnetic force are investi-
gated analytically and experimentally. The
beam is fixed at one end, and an alternat-
ing electromagnetic force acts on the mass
attached to the other end of the beam. The
governing partial differential equations are
solved by harmonic balance method, and
second order superharmonic and one-second
order subharmonic vibrations are obtained
as well as the harmonic vibration.

The work described in this paper was un-
dertaken as part of a program aimed at
predicting engine noise and vibration char-
acteristics at the design stage. The operat-
ing engine test and artificial excitation test
were carried out with a 4-cylinder, 1500 cc
gasoline engine. Radiated noise and vibra-
tion characteristics of a cylinder block were
investigated and noise controlling parame-
ters, such as radiation efficiency, forcing
functions and modal damping, were exam-
ined. Surface response level and radiated
noise from the cylinder block were calcu-
lated using a finite element model by
combining noise controlling parameters
obtained by the tests.

CYLINDERS

85-1895
**Flow-Induced Vibrations of Mixing Vessel
Internals**
R. King
BHRA, The Fluid Engrg. Ctr., Cranfield,
Bedford, UK
J. Vib., Acoust., Stress, Rel. Des., Trans.
ASME, 107 (2), pp 253-258 (Apr 1985) 10
figs, 11 refs

KEY WORDS: Cylinders, Submerged struc-
tures, Fluid-induced excitation

The results of research work on cylinders
excited to oscillate by flow within unbaffled
mixing vessels are presented. Oscillations
of an anchor mixer and of dip tubes are
described, including those cases in which
the cylinders are mounted close to the
vessel wall. The results are used to define
guidelines for calculating safe operating
limits of cylinders dipping into water, and
for avoiding vortex excited oscillations of
an anchor mixer by a device which actually
improves its efficiency as a mixer.

85-1896
**Calculation of Radiated Noise from Cylin-
der Block Using Finite Element Model**
K. Maekawa, S. Morita
Toyo Kogyo Co. Ltd., Hiroshima-shi, Japan
Intl. J. Vehicle Des., 6 (2), pp 228-239
(Mar 1985) 12 figs, 1 table, 6 refs

KEY WORDS: Cylinders, Engine noise,
Noise prediction, Finite element technique,
Modal analysis

FRAMES AND ARCHES

85-1897
**Active Reduction of Deflections and Vibra-
tions: Advantages, Problems, and Applica-
tions (Aktive Unterdruckung von
Durchbiegungen und Schwingungen: Vor-
teile, Probleme, Realisierungsmoglichkeiten)**
H. Domke, H. Bouten, H. Meyr, B. Zach
Lehrstuhl f. Konstruktive Gestaltung, Mies-
van-der-Rohe Str. 1, 51 Aachen, Fed. Rep.
Germany
Dynamische Probleme. Modellierung und
Wirklichkeit. Proc. of a Meeting, Oct 4-5,
1984, Hannover, Curt-Risch-Institut der
Universitat Hannover, Hannover, Fed. Rep.
Germany, Vol. II, pp 399-416, 15 figs, 6
refs (In German)

KEY WORDS: Supports, Active vibration
control

An active deflection control system for
cable-prestressed concrete support structures
is discussed. The control is achieved by
means of actively controlled coupling
members between the cable and support
structure. Smallest measured deflections
release reverse control instructions in the
coupling members, causing the deflection to
reverse. As a result of flexural freedom
each load in the concrete component results
in a uniformly distributed compression load,
while the cable deforms in such a manner
as if it were directly loaded.

MEMBRANES, FILMS, AND WEBS

KEY WORDS: Membranes, Damped structures

The problem of damping out the oscillations of a rectangular membrane by means of distributed forces is solved analytically. The membrane is initiated by given initial displacement and velocity conditions. The basic control problem is to minimize the deflection and the velocity of displacements in a given period of time with the minimum possible expenditure of force. The necessary conditions of optimality are obtained from a control theory approach and formulated in the form of a maximum principle in terms of an adjoint variable. Numerical results are given for various problem parameters and the efficiency of the control mechanism is investigated.

PANELS

KEY WORDS: Panels, Composite materials, Aircraft components, Acoustic fatigue, Temperature effects

Described is a sonic fatigue program to determine the effect of elevated temperature on flat integrally stiffened graphite/-epoxy panels. The program involved comparative sonic fatigue testing of two J-stiffened monolithic and two bladed-stiffened orthogrid panels, with one panel of each design tested at ambient temperature and the other at 254°F. Existing analysis methods are also evaluated. The elevated temperature could affect the sonic fatigue life of composite panels.

KEY WORDS: Panels, Aircraft wings, Frequency domain method

An accurate and effective method for calculations of unsteady three-dimensional supersonic flow has been developed. The method is capable of handling general cases of planar, coplanar, and nonplanar wing planforms in the complete frequency domain. A harmonic-gradient potential model is provided for elementary doublet panels to be made compatible with the wave number generated.

PLATES

KEY WORDS: Plates, Torsional excitation

An analytical solution is determined for the motion of an infinite elastic plate, excited by a torsional moment. The driving moment is sinusoidal in time and applied to an indenter with a circular base, fixed to the

plate. It is shown that the input admittance due to a soft indenter is larger than in the case of a rigid indenter and that the results for both cases, with consideration of the different stress distributions, are supported by the results previously gi en for a perfectly rigid indenter (obtained with mixed boundary conditions).

85-1902
Nonlinear Static and Dynamic Analysis of Circular Plates and Shallow Spherical Shells Using the Collocation Method
Y. Nath, P.C. Dumir, R.S. Bhatia
Indian Inst. of Tech., Delhi, India
Intl. J. Numer. Methods Engrg., 21 (3), pp 565-578 (1985) 12 figs, 2 tables, 21 refs

KEY WORDS: Circular plates, Spherical shells, Collocation method

The present work investigates the efficacy and applicability of interior global orthogonal point collocation method to the axisymmetric nonlinear analysis of elastic circular plates and shallow spherical shells subjected to uniformly distributed transverse load. Spacewise discretization is carried out using a polynomial expansion with the zeros of a Chebyshev polynomial as collocation points. The static response and snap-through buckling results, as well as, the dynamic response and dynamic buckling results under a uniformly distributed step load are obtained and found to agree closely with available results.

85-1903
Natural Frequencies of a Non Homogeneous Isotropic Elastic Infinite Plate of Variable Thickness Resting on Elastic Foundation
J.S. Tomar, D.C. Gupta, V. Kumar
Univ. of Roorkee, Roorkee, India
Meccanica, 19 (4), pp 320-324 (Dec 1984) 6 figs, 6 refs

KEY WORDS: Plates, Variable cross section, Elastic foundation, Natural frequencies

The dynamic free response of a nonhomogeneous isotropic elastic infinite plate of

parabolically varying thickness resting on an elastic foundation are studied. The frequencies, deflections and moments corresponding to the first five modes of vibration are computed for the two combinations of boundary conditions, clamped-clamped and clamped-simply supported and various values of taper constant, nonhomogeneity parameter and foundation modulus by applying the method of Frobenius for the solution of the governing differential equation of motion.

85-1904
A Note on Vibrating Circular Plates Carrying Concentrated Masses
P.A.A. Laura, P.A. Laura, G. Diez, V.H. Cortinez
Institute of Applied Mechanics and Universidad Nacional del Sur, 8111 Puerto Belgrano Naval Base, Argentina
Mech. Res. Comm., 11 (6), pp 397-400 (Nov/Dec 1984) 2 tables, 4 refs

KEY WORDS: Circular plates, Fundamental frequencies

This note deals with the approximate determination of the fundamental frequency of vibration of circular plates elastically restrained against rotation and carrying a concentrated mass at its center. In the case of clamped plates the results are in excellent agreement with values predicted by the exact solution. The present algorithmic procedure allows for the calculation of the fundamental frequency of vibration for any value of the flexibility coefficient in a very simple yet quite accurate fashion.

85-1905
Non-Linear Axisymmetric Transient Analysis of Orthotropic Thin Annular Plates with a Rigid Central Mass
P.C. Dumir, Y. Nath, M.L. Gandhi
Indian Inst. of Tech., New Delhi-110016, India
J. Sound Vib., 97 (3), pp 387-397 (Dec 8, 1984) 8 figs, 1 table, 8 refs

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The geometrically nonlinear, axisymmetric transient elastic response is determined of cylindrically orthotropic thin annular plates with a rigid central mass subjected to a uniformly distributed load on the plate as well as a central load on the rigid mass. The response of isotropic and orthotropic, clamped as well as simply supported, annular plates with a rigid central mass, subjected to step function and sinusoidal pulse loads, is calculated for two values of the annular ratio. The influence of the mass ratio and the magnitude of the step load on the deflection response is determined. The effect of mass ratio, amplitude and duration of sinusoidal pulse on the deflection response is also studied.

85-1906
Energy Propagation Velocity of Elastic Waves in Sandwich Layer

T. Ohyoshi
Akita Univ., Akita City, Japan 010

The explicit characteristic velocities of mechanical energy are obtained in computation for designing structures and acoustical inspections of a sandwich composite plate made of three elastic constituent layers. The dependence of the energy velocity upon the parameters such as ratio of shear velocity, volume fraction, and Poisson's ratios of constituent layers is discussed in graph form with curves of frequency to energy arrival time. Numerical calculations are carried out up to several higher modes within the range of practical frequencies.

85-1907
Acoustic Radiation from Single and Double Ribbed Circular Cylindrical Shells

C.B. Burroughs, S.I. Hayek, J.E. Hallander, D.A. Bostian
Pennsylvania State Univ., State College, PA

Measurements of the acoustic radiation from single and double ribbed circular cylindrical shells were made on the NUSC transducer calibration platform. Six different types of mechanical drives were used at each of three locations inside the inner shell. Analysis of the processed data is presented and discussed.

85-1908
Dynamics and Stability of Coaxial Cylindrical Shells Containing Flowing Fluid

M.P. Paidoussis, S.P. Chan, A.K. Misra
McGill Univ., Montreal, Quebec, Canada

An analytical model for the dynamics and stability of coaxial cylindrical shells conveying incompressible or compressible fluid in the inner shell and in the annulus between the two shells is presented. Shell motions are described by Flugge's thin-shell equations and the fluid forces are determined by means of linearized potential flow theory and formulated with the aid of generalized force Fourier transform techniques.

85-1909
A Comparison of Some Shell Theories Used for the Dynamic Analysis of Cross-Ply Laminated Circular Cylindrical Panels

K.P. Soldatos

Univ. of Ioannina, Ioannina, Greece

KEY WORDS: Shells, Panels, Layered materials

The free vibration problem of thin elastic cross-ply laminated circular cylindrical panels is considered. A theoretical unification, as well as a numerical comparison of the thin shell theories most commonly used, is presented. By using a closed form solution obtained for simply supported panels, a comparison of corresponding numerical results is attempted.

85-1910

A Numerical Approach for Vibration Analysis of an Axisymmetric Shell Structure with a Nonuniform Edge Constraint

Y.F. Hwang
David Taylor Naval Ship R&D Ctr., Bethesda, MD 20084

KEY WORDS: Shells, Bodies of revolution, Vibration analysis, Numerical methods

A numerical approach for computing the eigenvalues and eigenfunctions of an axisymmetric shell with a nonaxisymmetric edge constraint is presented. The shell structures are modeled without constraint by an assemblage of axisymmetric shell elements.

85-1911

Geometrically Non-Linear Transient Analysis of Laminated, Doubly Curved Shells

J.N. Reddy, K. Chandrashekhara
Virginia Polytechnic Inst. and State Univ., Blacksburg, VA 24061

KEY WORDS: Spherical shells, Cylindrical shells, Layered materials, Transverse shear deformation effects

A dynamic, shear deformation theory of a doubly curved shell is used to develop a finite element for geometrically nonlinear (in the von Karman sense) transient analysis of laminated composite shells. The element is employed to determine the transient response of spherical and cylindrical shells with various boundary conditions and loading. The effect of shear deformation and geometric nonlinearity on the transient response is investigated.

85-1912

Large Amplitude Free Vibrations of Shallow Spherical Shell and Cylindrical Shell — A New Approach

G.C. Sinharay, B. Banerjee
Hooghly Mohsin College, P.O. Chinsurah, Dist. Hooghly, West Bengal, India

KEY WORDS: Spherical shells, Cylindrical shells

Large amplitude free vibrations of thin elastic shallow spherical and cylindrical shells are investigated following a new approach. Numerical results for movable as well as immovable edge conditions are presented graphically and compared with other known results.

RINGS

85-1913

In-Plane Vibrations of Circular Rings

S.-I. Suzuki
Tsujido Higashikaigan 2-17-21, Fujisawa 251, Japan

KEY WORDS: Rings, Warping, Natural frequencies

Except in a few cases rings have been treated one-dimensionally as curved beams in analyses to determine their frequencies

of vibration. Consequently, for thick rings there are large discrepancies between theoretical and experimental results. In this paper an analysis is carried out in which account is taken of the warping of the cross section. The frequencies of free vibration are determined by using the principle of minimum total potential energy. Numerical calculations are made for a ring of rectangular cross section.

A philosophy for design of submarine pipelines on the seabed to resist ocean forces is proposed. The pipeline response to hydrodynamic forces is calculated and the predicted response parameters are compared with the permitted values given by the design criteria. Some guidelines are given to achieve compatibility of individual elements in the design procedure.

PIPES AND TUBES

85-1914
Acoustic Characteristics of Circular Bends in Pipes
D. Firth, F.J. Fahy
Inst. of Sound and Vib. Res., Univ. of Southampton, Southampton S09 5NH, UK
J. Sound Vib., 97 (2), pp 287-303 (Nov 22, 1984) 10 figs, 1 table, 13 refs

KEY WORDS: Sound waves, Mode shapes, Pipe joints. Piping systems

The acoustic properties of circular bends in pipework systems are investigated by calculation of the ode shapes and propagation constants of the acoustic modes of the bend, the torus modes, and by evaluation of the transmission and reflection coefficients at a bend in an otherwise infinite straight pipe. The coefficients for the first three cylinder and torus modes are plotted against frequency for the case of a plane wave incident upon a 90° bend. The pipe walls are assumed to be rigid.

85-1915
A Concept for Design of Submarine Pipelines to Resist Ocean Forces
I.. Karal
SINTEF, Trondheim, Norway
J. Energy Resources Tech., Trans. ASME, 107 (1), pp 42-47 (Mar 1985) 2 figs, 10 refs

KEY WORDS: Underwater pipelines, Hydrodynamic excitation, Design techniques

85-1916
Wave Speeds in Rotating Thick-Walled Elastic Tubes
D.M. Haughton
Univ. of Glasgow, Glasgow G12 8QW, Scotland
J. Sound Vib., 97 (1), pp 107-116 (Nov 8, 1984) 6 figs, 10 refs

KEY WORDS: Tubes, Torsional vibrations, Longitudinal vibrations

The wave speeds in rotating thick-walled circular cylinders of incompressible, isotropic, hyperelastic material at finite deformation are investigated. It is proved that pure torsional, longitudinal and breathing mode vibrations no longer exist when rotation is initiated. Numerical results are given for a number of different situations when an empirical three term Ogden strain-energy function is used. Comparisons are made with the corresponding results for membrane shells and solid cylinders.

85-1917
Heat Exchanger Tube Fretting Wear: Review and Application to Design
P.L. Ko
National Res. Council, Canada Western Lab., Vancouver, BC
J. Tribology, Trans. ASME, 107 (2), pp 149-156 (Apr 1985) 13 figs, 15 refs

KEY WORDS: Heat exchangers, Tubes, Supports, Fluid-induced excitation,

Flow-induced vibration in steam generators and heat exchangers can cause dynamic interactions between tubes and tube supports resulting in fretting-wear. The effects on

tube wear of various parameters, such as tube/support interactions, materials, and tube/support clearances have been studied. Techniques to predict the dynamic tube/-support interaction and analyze the impact force at the support have been developed. The results of this work are reviewed and discussed in the context of how best they may be applied in the assessment of heat exchanger designs.

The response of long floating structures to a harmonic excitation is the basis for the response calculation in a short-crested wave field. Consistent formulas for obtaining the nodal loads in a finite element analysis are presented. The accuracy of the method is compared with the results obtained using a Rayleigh-Ritz approximation of the response with continuous eigenfunctions. The error of using an irrational finite element model is demonstrated for comparison.

85-1918
Alternate Procedures for the Seismic Analysis of Multiply Supported Piping Systems
M. Subudhi, P. Bezler, Y.K. Wang, R. Alforque
Brookhaven National Lab., Upton, NY
Rept. No. BNL-NUREG-51773, 329 pp (Oct 1984) NUREG/CR-3811/GAR

KEY WORDS: Piping systems, Seismic analysis

Independent support motion methodologies have been used to analyze piping systems subjected to multiple support excitations. Methods to compute both the dynamic and pseudo-static components of response were investigated. In order to formulate a general procedure for predicting seismic response, a sample of six piping systems, two of which were subjected to thirty-three earthquakes, were analyzed. The dynamic component of response was evaluated considering fourteen variations of the combination sequence and procedure between modes, directions and support groups.

DUCTS

85-1920
Models for Describing Active Noise Control in Ducts
S.J. Elliott, P.A. Nelson
Univ. of Southampton, UK
ISVR Tech. Rept. No. 127, pp 1-61 (Apr 1984) 5 figs, 1 table, 24 refs

KEY WORDS: Ducts, Active noise control

A number of methods have been proposed for controlling the sound propagating in a duct by introducing secondary sources to cancel the original sound wave produced by a primary source. The physics of such active noise control systems is fairly straightforward and well understood. This report describes the technology associated with this process.

85-1921
Sound Transmission at Low Frequencies through the Walls of Distorted Circular Ducts
A. Cummings, I.-J. Chang
Univ. of Missouri-Rolla, Rolla, MO 65401
J. Sound Vib., 97 (2), pp 261-286 (Nov 22, 1984) 13 figs, 20 refs

KEY WORDS: Ducts, Sound transmission

A theoretical treatment of sound transmission through the walls of distorted circular ducts is given, for plane mode transmission within the duct. The transmission mecha-

85-1919
Finite Element Modeling of the Response of Long Floating Structures under Harmonic Excitation
C. Georgiadis
SINTEF, The Foundation of Scientific Industrial Res. at the Norwegian Inst. of Tech., Trondheim, Norway
J. Energy Resources Tech., Trans. ASME, 107 (1), pp 48-53 (Mar 1985) 12 figs, 10 refs

KEY WORDS: Floating structures, Harmonic excitation, Finite element technique

nism is essentially that of mode coupling, whereby higher structural modes in the duct walls are excited, because of the wall distortion, by the internal sound field. The theory is in two parts: an approximate analytical model for the structural response of the walls to the internal sound field, and a structural radiation model. Computed results, based on the theory, are compared to measurements on long-seam air conditioning ducts.

BUILDING COMPONENTS

85-1922
Analytical Models for the Nonlinear Seismic Analysis of Reinforced Concrete Structures
M. Keshavarzian, W.C. Schnobrich
Univ. of Illinois at Urbana-Champaign, Urbana, IL 61801
Engrg. Struc., Z (2), pp 131-142 (Apr 1985) 14 figs, 50 refs

KEY WORDS: Structural members, Reinforced concrete, Seismic analysis, Hysteretic damping

Analytical techniques for nonlinear dynamic analysis of reinforced concrete structures are discussed. The strain-rate effect, damping, and hysteretic behavior of structural members are reviewed. Three classifications of analytical models of RC structures are reviewed, and their applications to the different types of structural systems discussed.

ELECTRIC COMPONENTS

MOTORS

85-1923
Excitation Conditions of Flexural Traveling Waves for a Reversible Ultrasonic Linear Motor

M. Kuribayashi, S. Ueha, E. Mori
Tokyo Inst. of Technology, Midoriku, Yokohama 227, Japan
J. Acoust. Soc. Amer., 77 (4), pp 1431-1435 (Apr 1985), 10 figs, 7 refs

KEY WORDS: Motors, Beams, Flexural vibrations, Wave propagation

This paper presents a theory and experiments on a reversible ultrasonic linear motor, consisting of a thin beam, two ultrasonic transducers, and a slider. The slider rides upon the crests of transverse traveling flexure waves propagating down the beam from one transducer to the other.

ELECTRONIC COMPONENTS

85-1924
Taming Resonance in Servos
G.J. Schneider
Autocon Systems, Pleasanton, CA
Machine Des., pp 73-76 (Feb 7, 1985), 10 figs

KEY WORDS: Transducers, Resonant response, Servomechanisms

Resonant transducers used in motion control systems which can cause instability are described. The paper shows a simple network which can be used in the servo loop to counteract the resonance.

DYNAMIC ENVIRONMENT

ACOUSTIC EXCITATION

85-1925
The Application of a Biorthogonality Principle to the Solution of the End Problem of a Liquid-Filled Rectangular Viscous Acoustic Waveguide
W.F. Albers, E.J. Brunelle, H.A. Scarton

Rensselaer Polytechnic Inst., Troy, NY 12180-3590
J. Vib., Acoust., Stress, Rel. Des., Trans. ASME, 107 (2), pp 243-252 (Apr 1985), 7 figs, 8 refs

KEY WORDS: Waveguide analysis

This paper presents a biorthogonality property of the eigenfunctions for the acoustic modes of the rectangular, liquid-filled waveguide. It provides an immediate solution for the end condition expansion coefficients.

The forward and inverse problems of an extended, finite source of elastic waves in a thick plate are considered. The signals received at a point in the nearfield of a source are computed by a superposition of the signals found with a generalized ray algorithm from point sources of variable strength arranged along a straight line. Synthetic waveforms corresponding to several source types and spatial distributions on the surface and in the interior of the plate are shown. A processing algorithm is also developed which utilizes the signals detected at just one receiver point to obtain the solution to the inverse source problem.

85-1926
Resonances of Plates and Cylinders: Guided Waves
G. Maze, J.L. Izbicki, J. Ripoche
Université du Havre, Laboratoire d'Electronique et d'Automatique, Groupe "Ultrasons," U.E.R.S.T. Place Robert Schuman, 76610 Le Havre, France
J. Acoust. Soc. Amer., 77 (4), pp 1352-1357 (Apr 1985), 10 figs, 1 table, 27 refs

KEY WORDS: Sound waves, Wave scattering, Plates, Cylinders

The normal diffusion of an ultrasonic plane wave by cylinders and plates imbedded in water, showing resonances which are natural modes of vibration, is studied. When a natural mode of an elastic target is excited, energy stored during forced excitation is emitted at the end of the forced excitation. Backscattered spectra obtained by the Resonance Isolation and Identification Method from an aluminum cylinder showing supplementary resonances is observed.

85-1927
Analysis of Elastic Wave Signals from an Extended Source in a Plate
C. Chang, W. Sachse
Cornell Univ., Ithaca, NY 14853
J. Acoust. Soc. Amer., 77 (4), pp 1335-1341 (Apr 1985), 8 figs, 35 refs

KEY WORDS: Elastic waves, Wave propagation, Plates

85-1928
On the Time-Average Acoustic Pressure
K. Beissner
Information from the Physikalisch-Technische Bundesanstalt, Braunschweig
Acustica, 57 (1), pp 1-4 (Jan 1985) 19 refs

KEY WORDS: Sound pressures

The time-average acoustic pressure in Eulerian coordinates is an important part of the radiation pressure. It has been dealt with in the literature mainly in two different ways, one of which refers to the general case of a three-dimensional field. These are discussed and compared and their equivalence in the one-dimensional case is shown.

85-1929
Soil Impedance Measurement by an Acoustic Pulse Technique
C.G. Don, A.J. Cramond
Chisolm Inst. of Tech., Caulfield East, 3145 Victoria, Australia
J. Acoust. Soc. Amer., 77 (4), pp 1601-1609 (Apr 1985) 16 figs, 14 refs

KEY WORDS: Soils, Impedance, Measurement techniques, Acoustic pulses,

Impulses generated by the discharge of a rifle cartridge have been used to determine the complex acoustic impedance of grassland, cultivated earth, a layered forest

floor, and highly reflecting stone impregnated ground.

85-1930
Relations Among Different Frequency Rating Procedures for Traffic Noise
D.R. Flynn, S.L. Yaniv
National Bureau of Standards, Gaithersburg, MD 20899
J. Acoust. Soc. Amer., _77_ (4), pp 1436-1446 (Apr 1985) 6 figs, 9 tables, 24 refs

KEY WORDS: Traffic noise, Rating

A series of calculations was to ascertain how well one frequency-weighted rating, such as weighted sound level, loudness level, or perceived noise level, may be predicted from another such rating. A total of 103 average sound level spectra, measured at several distances from different types of highways, was used in these calculations.

85-1931
Factors Influencing dB(A) Ratings for Sound Insulation: Incident Noise Spectrum and Shape of the Transmission Loss Curve
A. Moreno
Instituto de Acustica, Serrano 144, Madrid 6, Spain
J. Sound Vib., _97_ (2), pp 337-348 (Nov 22, 1984) 9 figs, 22 refs

KEY WORDS: Acoustic insulation, Sound transmission loss

A computer study of the influence of both the incident noise spectrum and the shape of the transmission loss curve on dB(A) ratings for assessing acoustical insulation is undertaken.

85-1932
Asymptotic Fluid-Structure Interaction Theories for Acoustic Radiation Prediction
H. Huang, Y.F. Wang
Naval Surface Weapons Ctr., White Oak, Silver Spring, MD 20910

J. Acoust. Soc. Amer., _77_ (4), pp 1389-1394 (Apr 1985) 11 figs, 11 refs

KEY WORDS: Fluid-structure interaction, Sound waves, Wave radiation

It is well known that at extremely high or low frequencies, the fluid-structure interaction effects can be represented asymptotically by simple equations. Thus, it appears that an optimum computation scheme for predicting acoustic pressure field radiated from a submerged elastic structure could be a combination of various asymptotic theories and the exact formulation. This paper explores the ranges of applicability of some asymptotic theories, using the problem of radiation from a spherical elastic shell as the bench mark.

85-1933
Analysis of Higher-Order Mode Effects in the Circular Expansion Chamber with Mean Flow
Jeong-Guon Ih, Byung-Ho Lee
Dept. of Test and Experiments, Tech. Ctr., Daewoo Motor Co., Buk-ku, Inchon, Korea
J. Acoust. Soc. Amer., _77_ (4), pp 1377-1388 (Apr 1985) 10 figs, 26 refs

KEY WORDS: Mufflers, Acoustic absorption, Noise control

The effects of higher-order acoustic modes produced by the areal discontinuities of the simple expansion chamber with mean flow on the acoustic performance are studied. The chamber is modeled as a piston-driven circular rigid tube with no losses and, by using the Fourier-Bessel expansion, a general expression of the output pressure to the given input uniform volume velocity is obtained for a whole chamber.

85-1934
Measurement of Sound Absorption in Low Salinity Water of the Baltic Sea
H.G. Schneider, R. Thiele, P.C. Wille
Forschungsanstalt der Bundeswehr f. Wasserschall- und Geophysik, Klausdorfer Weg 2-24, D-2300 Kiel, Fed. Rep. Germany

KEY WORDS: Acoustic absorption, Oceans

Shallow water propagation measurements in the thermocline-halocline refractive sound channel of the Baltic Sea are utilized to estimate the absorption coefficient in low salinity water. The lower margin of the present data which are derived from transmission loss by subtraction of cylindrical spreading can be represented by the Francois and Garrison formula of 1982.

85-1935
Reverberation Time in Enclosures: The Surface Reflection Law and the Dependence of the Absorption Coefficient on the Angle of Incidence
G. Benedetto, R. Spagnolo
Istituto Elettrotecnico Nazionale Galileo Ferraris, Corso Massimo d'Azeglio 42, Torino, Italy

KEY WORDS: Enclosures, Acoustic absorption

The sound decay and reverberation time of enclosures depend on the amount of randomization achieved during the decay. The randomization is determined by the degree of surface roughness and absorptivity and is also related to the shape of the enclosure. Many authors showed that, even in the hypothesis of a memoryless reflection law, the reverberation time largely varies when the absorptivity is nonuniformly distributed on the surfaces, for a fixed value of the sound absorption coefficient. In this paper, applyi ' a ray-tracing simulation procedure to a simple two-dimensional enclosure, the effect is shown to be still stronger when a certain fraction of specular reflection is taken into account.

85-1936
On the Production and Absorption of Sound by Lossless Liners in the Presence of Mean Flow

M.C. Quinn
Univ. of Southampton, Southampton S09 5NH, UK

KEY WORDS: Acoustic linings, Sound generation, Acoustic absorption

The interaction of sound with the leading and trailing edges of a nominally lossless acoustic liner is examined in the presence of mean flow. It is argued that acoustic energy is conserved only if the whole flow is irrotational. In practice the sound induces vorticity production at the liner, and in particular that generated at the edges of the liner leads to a net transfer of energy between the acoustic field and the mean flow. Analytical results are given for a pressure release liner in a rigid plane wall.

85-1937
Near-Field Frequency-Domain Theory for Propeller Noise
D.B. Hanson
Hamilton Standard, Windsor Locks, CT

KEY WORDS: Propellers, Noise generation, Frequency domain method, Near field region

Near field noise equations are developed from the author's helicoidal surface theory for propeller aerodynamics and noise. Thickness, steady loading, and quadruple sources are included. Apart from the thin-blade approximation and neglect of radial source terms, the equations are exact.

85-1938
Computation of Far-Field Sound Generation in a Fluid-Structure Interaction Problem
A.T. Conlisk
Ohio State Univ., Columbus, OH 43210

The inviscid flow past a bump on a plane
wall in which vorticity disturbances initially
placed upstream convect downstream and
interact with the bump is examined.

85-1941
Blast Door and Entryway Design and Evaluation
D.W. Hyde, S.A. Kiger
Army Engineer Waterways Experiment Station, Vicksburg, MS

SHOCK EXCITATION

85-1939
Structural Instability in Fluid-Structure Systems under Hydrodynamic Shock Conditions
N. Akkas, J.E. Jackson, Jr.
Middle East Technical Univ., Ankara, Turkey

KEY WORDS: Fluid-structure interaction,
Shock wave propagation

The effects of nonlinear fluid-structure
interaction on the dynamic buckling of
structures are investigated. Structural buckling characteristics are studied for the case
of a strong shock wave propagating through
a fluid medium striking a structure. Nonlinear terms are retained for both fluid and
structural systems. A one-dimensional
example consisting of a perfect gas-springmass system is solved for shock wave loading.

KEY WORDS: Blast resistant structures,
Doors, Reinforced concrete

Objectives of this project were to design
and test a walk-in, reinforced concrete
blast shelter entryway and blast door. Two
door configurations were designed, constructed, and tested: a commercially available standard exterior door with special
supports, and 3-inch-thick reinforced concrete door.

85-1942
**Modal Analysis Applied to the DAA Model
for Fluid Structure Interaction in Underwater Shock**
J.H. Ginsberg, C.E. Rosenkilde
School of Mech. Engrg., Georgia Inst. of
Tech., Atlanta, GA

85-1940
**Calculation of Shock Problems by Using
Four Different Schemes**
W.H. Lee, P.P. Whalen
Los Alamos National Lab., NM

KEY WORDS: Shock response

Results are shown of the use of several
different shock treatments in one-and two-
dimensional Lagrangian code calculations of
strong shock problems with known solutions.
The shock treatments are von Neumann-

KEY WORDS: Modal analysis, Fluid-structure interaction, Doubly asymptotic approximation, Underwater structures, Shock waves

Past studies of the response of cylindrical
types of pressure vessels to underwater
shock waves have treated relatively simple
cases of incidence such as broadside. The
present study develops a general algorithm
for shock response in which a variety of
effects can be described in modular form.
The concept is then used to investigate a
case of oblique incidence. The overall
technique employs the doubly asymptotic
approximation of fluid-structure interaction,

but in the less well-known modal expansion form. A general procedure is outlined.

85-1943
Mach Reflection Flowfields Asociated with Strong Shocks
H. Mirels
The Aerospace Corp., El Segundo, CA
AIAA J., 23 (4), pp 522-529 (Apr 1985) 7 figs, 3 tables, 9 refs

KEY WORDS: Shock waves, Wave reflection

The Mach reflection associated with the passage of a shock wave over a wedge is treated in the limit of an ideal gas and a strong shock. Characteristic velocities in the recirculation region associated with double-Mach reflection are estimated. Local surface pressure maxima at the upstream and downstream edges of the recirculation region are also estimated.

85-1944
Unsteady Laminar Boundary-Layer Separation on Oscillating Configurations
W. Geissler
DFVLR, Gottingen, Fed. Rep. Germany
AIAA J., 23 (4), pp 577-582 (Apr 1985) 6 figs, 17 refs

KEY WORDS: Boundary layer excitation, Plates, Airfoils, Finite difference technique

A finite difference procedure has been developed to calculate unsteady two-dimensional laminar boundary layers on oscillating configurations. The method works in regions of reversed flow without numerical difficulties. The oscillating flat plate is investigated as a first test case to prove the validity and efficiency of the calculation procedure. The method is then applied to the case of an airfoil with pitching oscillations.

85-1945
The Effects of Seismic Waves
S. De

National Research Inst., P.O. Bankisol, Bankura, W. Bengal, India
Shock Vib. Dig., 17 (2), pp 3-32 (Feb 1985) 370 refs

KEY WORDS: Seismic response, Ground motion, Earthquake prediction, Reviews

This review article deals with the effects of seismic waves on ground motion and structures, mechanisms and prediction of earthquakes, abnormal animal behavior before earthquakes, and disturbances in the ionosphere. Some recent problems in seismology are described.

VIBRATION EXCITATION

85-1946
Transonic Time Responses of the MBB A-3 Supercritical Airfoil Including Active Controls
J.T. Batina, T.Y. Yang
Purdue Univ., West Lafayette, IN
J. Aircraft, 22 (5), pp 393-400 (May 1985) 12 figs, 3 tables, 20 refs

KEY WORDS: Airfoils, Aeroelasticity, Time response loops, Fluid-induced excitation

Aeroelastic time-response analyses are performed for the MBB A-3 supercritical airfoil in small-disturbance transonic flow based on the use of transonic code LTRAN2-NLR. Three degrees of freedom are considered: plunge, pitch, and aileron pitch. The main objective was to investigate the applicability and accuracy of state-space aeroelastic modeling for two-dimensional airfoils with active controls in transonic flow. A state-space aeroelastic model was formulated using a Pade aerodynamic approximation. The resulting equations are explicitly solved in the time domain yielding the aeroelastic displacement responses.

85-1947
The Mode-Amplitude Technique and Hierarchial Stress Elements — A Simplified and Natural Approach

J. Robinson
Robinson and Associates, Horton Rd., Wood-
lands, Wimborne, Dorset, UK

KEY WORDS: Mode-amplitude technique,
Finite element technique, Stress elements

The derivation procedure of conventional
stress-based elements is reviewed and it is
shown how the procedure can be simplified
using degrees-of-freedom which are ampli-
tudes of the boundary loading modes (mode-
amplitude technique). This gives one class
of element based on stress assumptions and
uses only one virtual principle. The natu-
ral formulation of hierarchical stress ele-
ments is shown.

85-1948

**Quenching of a Primary Resonance by a
Combination Resonance of the Additive or
Difference Type**

A.H. Nayfeh
Virginia Polytechnic Inst. and State Univ.,
Blacksburg, VA 24061

KEY WORDS: Resonant response, Single
degree of freedom systems

An investigation is presented of the interac-
tion of primary resonances and combination
resonances of the additive and difference
types in single-degree-of-freedom systems
with quadratic and cubic nonlinearities. The
method of multiple scales is used to derive
two coupled first order ordinary differential
equations that describe the evolution of the
amplitude and phase with damping, nonlin-
earity and both primary and combination
resonances.

85-1949

Harmonic Analysis of Time-Limited Signals

M. Petternella, R. Vitelli
Facolta di Ingegneria, Universita Tor Ver-
gata, Via O. Raimondo, 00173, Roma, Italy

KEY WORDS: Harmonic analysis, Pulse
excitation

The problem of the estimation of the har-
monic content of a signal is studied. The
study is limited to the class of causal sig-
nals which are the response of linear stable
systems to pulse inputs. Two cases are
examined: the output of a system whose
model has one real pole; the output of a
system whose model has a complex conju-
gate pole pair. An analytical expression
for the error that arises when using the
finite Fourier transform is obtained.

85-1950

**Contribution to the Linear Dynamic Analy-
sis of Slender Bodies in Low and Medium
Frequency Ranges**

P. Gibert
Office National d'Etudes et de Recherches
Aerospatiales, B.P. 72, 92322 Chatillon
Cedex, France

KEY WORDS: Vibration analysis, Linear
theories, Aircraft fuselages

New methods of analysis of slender bodies
in the low- and medium-frequency ranges
are introduced. In the medium-frequency
range, the modes can be expected to be
very oscillatory along the axis of the body.
For this reason, the use of standard nu-
merical calculation methods, such as the
finite element method, is accompanied by
severe practical difficulties. The alterna-
tive technique proposed here is of W.K.B.J.
type, well-known in quantum mechanics.

85-1951

**Parametric Excitation in a Self-Exciting
System (2nd Report, Behaviors in the Re-
gions of Resonances of Orders 1/3 and 2)**

S. Yano
Fukui Univ., 3-9-1, Bunkyo, Fukui, Japan

KEY WORDS: Parametric excitation, Self-
excited vibrations, Subharmonic oscillations,
Nonlinear theories

In a self-exciting system of Van der Pol type with the restoring force expressed as the product of a nonlinear function of deflection and a periodic function of time self-excitation and parametric excitation induce resonances of higher orders than orders 1 and 1/2. Behavior in the region of subharmonic resonance of order 1/3 are investigated in the phase plane by using the averaging method. An approximate solution and the stability of a parametric resonance of order 2 is determined.

MECHANICAL PROPERTIES

DAMPING

85-1952
Accuracy of Consistent and Lumped Viscous Dampers in Wave Propagation Problems
Y.K. Chow
National Univ. of Singapore, Singapore
Intl. J. Numer. Methods Engrg., 21 (4), pp 723-732 (Apr 1985), 7 figs, 4 tables, 6 refs

KEY WORDS: Viscous damping, Wave propagation, Finite element technique, Boundary layer damping

This paper examines the use of frequency-independent viscous dampers in the study of wave propagation in unbounded solids, in conjunction with the finite element method. These dampers can be used in the frequency or in the time domain. In modeling the infinite domain using viscous dampers, Lysmer and Kuhlemeyer have conveniently lumped the dampers at the nodes and reasonable results have been obtained. Subsequently, this idea of lumping the dampers has been used by other researchers (e.g Dungar and Eldred). Theoretically, the dynamic stress condition imposed by the viscous dampers at the truncated boundary is continuous and thus should be treated as such. A consistent formulation of the viscous damper boundary using the finite element approach will lead to a damping matrix coupling the boundary nodes of the element. The accuracy of the solution obtained with this consistent formulation of the viscous damping matrix was evaluated. The effect of lumping this viscous damping matrix was also examined.

85-1953
On the Use of Exact Modal Analysis Techniques in the Design of Damping Devices for Multi-Conductor Overhead Power Lines, Part I: The Control of Aeolian Vibration
A. Simpson, P.S. Sembi
Univ. of Bristol, Bristol BS8 1TR, UK
J. Sound Vib., 97 (3), pp 357-385 (Dec 8, 1984), 10 figs, 12 refs

KEY WORDS: Dampers, Transmission lines, Modal analysis, Vibration control, Wind-induced excitation

A mathematical model of a multi-conductor overhead power line with spacer-dampers is presented. Advanced methods of exact modal and response analysis, requiring no more than single-precision computational accuracy, are used to develop a method for spacer-damper design which requires no more computational power than that of a standard microcomputer. An outline is presented of the application of this method to the control of Aeolian vibration by using self-damping spacers.

85-1954
Analysis of an Oscillatory Oil Squeeze Film Containing a Central Gas Bubble
S. Haber, I. Etsion
Technion -- Israel Inst. of Technology, Haifa, Israel
ASLE, Trans., 28 (2), pp 253-260 (Apr 1985), 9 figs, 7 refs

KEY WORDS: Squeeze-film dampers

A squeeze-film damper, consisting of two circular plates having only normal oscillatory relative motion is considered. The liquid lubricant between the plates is assumed to contain a single central gas bubble. The effect of the bubble on the damper performance is analyzed. Comparison is made

with the performance of a pure liquid damper.

85-1955
Stiffness and Damping Coefficients of Rubber
M.I. Abdulhadi
Yarmouk Univ., Irbid, Jordan
Shock Vib. Dig., 17 (5), pp 3-9 (May 1985)
6 figs, 4 refs

KEY WORDS: Damping coefficients, Stiffness coefficients, Elastomers, Reviews

A study has been carried out on a rubber pad (Neoprene GN) in the shape of a solid circular cylinder. The pad is subjected to a vibrating force. A mathematical model is used to evaluate stiffness and damping coefficients for the rubber and the damped energy. A heat conduction equation describing the temperature field in the rubber specimen is formulated; analytical results agree fairly well with temperatures measured in the rubber.

85-1957
Recent Progress in the Dynamic Plastic Behaviour of Structures, Part IV
N. Jones
Univ. of Liverpool, Liverpool, L69 3BX, UK
Shock Vib. Dig., 17 (2), pp 35-47 (Feb 1985) 118 refs

KEY WORDS: Dynamic buckling, Beams, Plates, Shells, Crashworthiness

This article surveys literature published on the dynamic plastic behavior of structures since the previous review in 1981. It focuses on additional work on the effects of transverse shear and rotatory inertia; recent publications on beams, plates, and shells; and dynamic plastic buckling. Some comments on scaling and structural crashworthiness are included.

WAVE PROPAGATION

FATIGUE

85-1956
Acoustic Emission Monitoring of Fatigue in 7010 Aluminum Alloys
G. Weatherly, J.M. Titchmarsh, C.B. Scruby
UKAEA Atomic Energy Res. Establishment, Harwell, UK
Rept. No. AERE-R-11167, 43 pp (Mar 1984)
N85-12152/3/GAR

KEY WORDS: Fatigue life, Acoustic emission, Aluminum

Acoustic emission (AE) was monitored in test-pieces of 7010 aluminium alloy containing growing fatigue cracks. Both high purity and commercial casts were studied in underaged, peak and overaged conditions.

85-1958
Diffraction of Rayleigh Waves in a Half-Space. I. Normal Edge Crack
B.Q. Vu, V.K. Kinra
Naval Ocean Systems Ctr., Code 9322, San Diego, CA 92152
J. Acoust. Soc. Amer., 77 (4), pp 1425-1430 (Apr 1985) 8 figs, 22 refs

KEY WORDS: Rayleigh waves, Wave diffraction, Cracked media

This paper is concerned with the diffraction of Rayleigh surface waves by an edge-crack normal to the free surface of a half-space. An experimental technique was developed to yield accurate and reproducible measurements of the scattered field on the free surface both in the vicinity of the crack and far away from it.

EXPERIMENTATION

MEASUREMENT AND ANALYSIS

85-1959
Digital Acceleration Measurement by Means of Microcomputers (Digitale Drehbeschleunigungsmessung mit Hilfe eines Mikrorechners)
D. Severin, P.L. Hartwig
Technische Universitat Berlin, Jebensstrasse 1, D-1000 Berlin 12, Fed. Rep. Germany
Techn. Messen-TM, 51 (11), pp 405-407 (Nov 1984), 4 figs, 8 refs (In German)

KEY WORDS: Acceleration measurement, Measuring instruments

The acceleration in rotating drives will be used more and more to optimize control systems. Pulse generators may be a useful alternative to the common acceleration sensors. In the present paper a microcomputer calculates the acceleration function using two consecutive impulses of a pulse generator. The system is based on measuring time intervals. By superposing a constant turning speed and the input signal, the acceleration can be determined even by low speed.

85-1960
Scanning Laser Doppler Vibration Analysis System (Flachenabtastendes Laser-Doppler-Schwingungsanalysesystem)
B. Stoffregen
Volkswagenwerk AG, Forschung-Messtechnik-Optik, D-3180 Wolfsburg 1
Techn. Messen - TM, 51 (11), pp 394-397 (Nov 1984), 7 figs, 5 refs (In German)

KEY WORDS: Vibration measurement, Measuring instruments, Lasers

The vibration velocity of object surface points can be measured by means of laser Doppler techniques (laser-Doppler-vibrometry). Based on this effect a new measuring system "SOVAS" (Scanning Optical Vibration Analysis System) has been developed. It analyzes the vibration amplitude of whole surface areas by means of computer controlled laser scanning and fast Fourier transform of the velocity signals. As a result, single or averaged frequency spectra as well as vibration patterns of up to seven frequency ranges can be displayed.

85-1961
An Adaptation of the Discrete Fourier Transform for the Determination of Modal Parameters of a Structure (Ein an die diskrete Fourier Transformation angepasstes Verfahren zur Bestimmung der modalen Parameter einer Struktur)
D. Bouchard, H. Waller
Institut f. Mechanik, Ruhr-Universitat Bochum, Fed. Rep. Germany
Dynamische Probleme. Modellierung und Wirklichkeit. Proc. mtg., Oct 4-5, 1984, Hannover, Curt-Risch-Institut der Universität Hannover, Hannover, Fed. Rep. Germany, Vol. II, pp 321-336, 10 figs, 2 refs (In German)

KEY WORDS: Modal analysis, Discrete Fourier transform

Free vibrations of a linear system can be represented by a sum of exponentially damped sinus functions. The proposed method is based on two ideas: the analytical fourier transform of an exponentially damped sinus function is calculated and its relationship with the discrete fourier transform is investigated; the inaccuracies of the analysis caused by the superposition of discrete Fourier transform can be eliminated by iteration. Thus systematic errors, which frequently cause difficulties in vibration analysis, can be eliminated and it is not necessary to employ windows or band spread analysis. Only a few periods of a signal need to be investigated.

85-1962
Theoretical and Experimental Study of Modal Interaction in a Two-Degree-of-Freedom Structure
A.G. Haddow, A.D.S. Barr, D.T. Mook

Univ. of Dundee, Dundee DD1 4HN, Scotland

KEY WORDS: Modal analysis, Two degree of freedom systems

For a two-degree-of-freedom structure, an experimental and theoretical investigation has been made of the primary resonances of the system, which occur when the frequency of excitation is near one of the natural frequencies.

85-1963
A More General Method of Substructure Mode Synthesis for Dynamic Analysis
J.H. Kuang, Y.G. Tsuei
Univ. of Cincinnati, Cincinnati, OH

KEY WORDS: Modal synthesis, Substructuring methods, Undamped structures

A method of substructure mode synthesis for determining the dynamic characteristics of an undamped system in a specified frequency band is investigated. The motion of each substructure is represented by the three mode sets: inertia, selected normal, and residual modes.

DYNAMIC TESTS

85-1964
Tracked Vehicle Test Plant for the Simulation of Dynamic Operation
I.C. Schmid
Hochschule der Bundeswehr, Hamburg, Germany

KEY WORDS: Test facilities, Tracked vehicles

A modern test plant in Germany has the capability to simulate not only rolling resistance, but also the inertia of vehicle mass and the turning resistance of a tracked vehicle. The dynamic loads of real vehicle action on the road and in the terrain can be run on the test stand.

85-1965
Model Mount System for Testing Flutter
M.G. Farmer
NASA Langley Res. Ctr., Hampton, VA
U.S. Patent No. 4-475 385

KEY WORDS: Mountings, Wind tunnels, Flutter, Airfoil, Aircraft

A wind tunnel model mount system is disclosed for effectively and accurately determining the effect of attack and airstream velocity on a model airfoil or aircraft. Conventional instrumentation is employed to effect model rotation through a turntable and to record model flutter data as a function of the angle of attack versus dynamic pressure.

85-1966
Seismic Simulation at C-E
K.H. Haslinger
Dynamic Testing Combustion Engineering, Inc., Windsor, CT

KEY WORDS: Seismic response, Simulation, Test facilities

C-E's seismic simulation test system, recently upgraded to meet current and future nuclear power industry standards in seismic testing, is described.

85-1967
Dynamic Investigation of Composite Structures — Process Controlled Computer Testing and Measurement ((Dynamische Untersuchungen an Verbundkonstruktionen — Prozessrechnergesteuerte Versuchs- und Messtechnik

W. Hanenkamp, W. Hammer
Ruhr-Universität Bochum, Institut f. Kon-
struktiven Ingenieurbau, Fed. Rep. Germany
Dynamische Probleme. Modellierung und
Wirklichkeit. Proc. of a Meeting, Oct 4-5,
1984, Hannover, Curt-Risch-Institut der
Universität Hannover, Hannover, Fed. Rep.
Germany, Vol. II, pp 357-376, 14 figs, 2
refs (In German)

KEY WORDS: Fatigue tests, Composite
structures, Girders, Computer aided tech-
niques

The hardware and software of a process
control computer system for dynamic testing
and measurement of composite structural
components is presented. The system is il-
lustrated in a fatigue test of composite
girders and steel shell covered buildings.

85-1968
Multiaxial Simulation of Dynamic Processes
(Mehraxiale Simulation dynamischer Vor-
gange)
P. Pantucek, V. Grubisic
Fraunhofer-Institut f. Betriebsfestigkeit
(LBF), Darmstadt, Fed. Rep. Germany
Dynamische Probleme. Modellierung und
Wirklichkeit. Proc. of a Meeting, Oct 4-5,
1984, Hannover, Curt-Risch-Institut der
Universität Hannover, Hannover, Fed. Rep.
Germany, Vol. II, pop 337-356, 12 figs, 12
refs (In German)

KEY WORDS: Test equipment, Aircraft,
Ground vehicles

The shortcomings and limitations of servo-
hydraulic test machines for the determinati-
on of strength and useful life of aircraft or
ground vehicles, or their components are
discussed. To eliminate these effects, an
improved hardware is proposed, which in-
cludes a multiaxial excitation component
and a semirigid restraint of defined stiff-
ness and conventional control electronics.

85-1969
Validation of Track Geometry Input to the
Vibration Test Unit (VTU) and Endurance
Capability of the VTU
B.R. Rajkumar, F.D. Irani
Assn. of American Railroads, Pueblo, CO
Rept. No. TCC-3(FRA-FR84), FRA/ORD-
84/09, 59 pp (June 1984) PB85-111995/GAR

KEY WORDS: Test facilities, Railroad
tracks

This report describes a series of tests con-
ducted to validate two forms of track
geometry inputs to the vibration test unit
(VTU), capable of reproducing actual reve-
nue track conditions. The first form con-
sisted of reformatted Plasser geometry
input. The second track geometry input
was developed based on the locomotive
track hazard detector concept.

85-1970
Nondestructive Testing of Resin Mortar
Using Ultrasonic Pulses
T. Morimitsu, T. Yabuta, T. Tsujimura, T.
Nakayama
Ibaraki Electrical Communication Lab.,
Nippon Telegraph and Telephone Corp.,
Tokai, Ibaraki-ken, 319-11, Japan
J. Vib., Acoust., Stress, Rel. Des., Trans.
ASME, 107 (2), pp 229-234 (Apr 1985) 13
figs, 8 refs

KEY WORDS: Dynamic tests, Ultrasonic
techniques, Tunnel linings

A quick-setting resin mortar, developed to
accomplish a new small diameter shield
tunneling method, is described. A nonde-
structive testing method employing ultrasonic
pulses is used for estimating the strength of
resin mortar. Young's modulus, the density,
the strength, and the ultrasonic velocity of
resin mortar of varying contents are meas-
ured.

85-1971
Progress Toward Magnetic Suspension and
Balance Systems for Large Wind Tunnels
C.P. Britcher
NASA Langley Res. Ctr., Hampton, VA
J. Aircraft, 22 (4), pp 264-269 (Apr 1985)
14 figs, 13 refs

KEY WORDS: Wind tunnels, Magnetic suspension systems, Aircraft, Test facilities

Recent developments and current research efforts leading toward realization of a large-scale production wind tunnel magnetic suspension and balance facility are reviewed. Progress has been made in the areas of model roll control, high-angle-of-attack testing, digital system control, calibration techniques, high magnetic moment superconducting solenoid model cores, and system failure tolerance.

Among the factors leading to destructive instability of rotors in high-speed, high-performance turbomachinery is excessive rubbing between rotating and stationary parts. This paper proposes a mathematical rationale of rubbing identification; defines the limits between benign contact and the initiation of a destructive instability based on harmonic spectral data; correlates the results with industry experience, published findings, and extensive laboratory tests; and details the response format of diagnostic data in actual cases.

DIAGNOSTICS

MONITORING

Studies on the Vibration and Sound of Defective Rolling Bearings (Third Report, Vibration of Ball Bearing with Multiple Defects)
T. Igarashi, J. Kato
Technological Univ. of Nagaoka, Kamitomioka-cho, Nagaoka, Niigata, Japan

KEY WORDS: Diagnostic techniques, Roller bearings, Ball bearings

A procedure for diagnosing the extent of rolling bearing defects from their vibration and sound is investigated. The vibration of a ball bearing with multiple dents on the race surface of either the inner or outer ring was studied.

Differentiating Rotor Response Due to Radial Rubbing
R.F. Beatty
Rockwell International, Canoga Park, CA 91304

KEY WORDS: Diagnostic techniques, Rotors, Turbomachinery, Rubs

The Development of Structural Monitoring Systems, Chebyshev and Maximum Likelihood Evaluation Methods (Zur Entwicklung von strukturellen Oberwachungssystemen, Tschebyscheff- und Maximum-Lilkelihood Schatzverfahren)
W. Wedig
Universitat Karlsruhe, 75 Karlsruhe, Kaiserstr., 12

KEY WORDS: Monitoring techniques, Chebyshe. method, Maximum likelihood method

In the development of a structural monitoring system the aim is to analyze stochastic residual vibrations of an elastic structure and to obtain from it dependable information about eventual changes in the stiffness parameters. Parameter identification methods, derived by means of a filter technique or maximum likelihood method, are suitable only when only a few parameters of the high frequency system are to be measured, or a large amount of measured data or a-priori knowledge is available. These difficulties are caused by low convergence of all evaluation methods. This problem is investigated in a low pass system which is

simulated in its time discrete form. Evaluation by means of the maximum likelihood method is obtained and explained. By the introduction of Chebyshev measure, which is evaluated by an optimization method, the convergence behavior of the maximum likelihood evaluation is considerably improved.

method due to Collins expanding on a procedure by Keller. The quadratically nonlinear case is not a trivial variation over the cubically nonlinear case that was presented in preceding papers.

85-1975
Signal Extraction for Automatic Monitoring of Machine Tool Drives (Signalgewinnung zur automatischen Cherwachung von Werkzeugmaschinenantrieben)
P. Menz, H. Heinke
Technische Hochschule Otto von Guericke Magdeburg
Maschinenbautechnik, 33 (12), pp 544-547 (1984) 7 figs, 1 table, 7 refs (In German)

KEY WORDS: Monitoring techniques, Machine tools

Automatic monitoring of components or whole machine tools has become increasingly important. The selection of suitable measured values is essential. A sensor with strain resistant gauges can complexly record several measured values.

85-1977
Resonant Non-Linear Waves — IV. Continuous and Discontinuous Solutions and an Assessment of Modal Analyses
M. Can, A. Askar
Istanbul Technical Univ., Maslak, Istanbul, Turkey
Intl. J. Nonlinear. Mech., 20 (2), pp 113-119 (1985) 4 figs, 6 refs

KEY WORDS: Boundary value problems, Resonant frequencies, Modal analysis

This paper indicates that near resonances many nonlinear systems develop discontinuous solutions and discusses the range of applicability of the single mode analysis. The discussion is based on the construction of an exact solution to a nonlinear integro-differential equation derived by a method due to Collins expanding on a procedure by Keller and applied to various problems in preceding articles.

ANALYSIS AND DESIGN

ANALYTICAL METHODS

85-1976
Resonant Non-Linear Waves — III. Elastic Continuum with Quadratic NonLinearity
M. Can, A. Askar
Istanbul Technical Univ., Maslak, Istanbul, Turkey
Intl. J. Nonlinear. Mech., 20 (2), pp 103-111 (1985) 1 fig, 5 refs

KEY WORDS: Boundary value problems, Resonant frequencies, Elastic media

The paper derives the relevant nonlinear integro-differential evolution equation by the

85-1978
Two-Sided Estimates in Linear Elastodynamics
A.A. Liolios
Aristotle-University of Thessaloniki, Thessaloniki, Greece
Mech. Res. Comm., 11 (6), pp 363-371 (Nov/Dec 1984), 1 fig, 12 refs

KEY WORDS: Boundary value problems, Elastodynamic response

Methods of bounding from above and below the solutions of self-adjoint boundary value problems in linear elastostatics are extended to linear problems in elastodynamics. A procedure is presented which provides two-sided solution estimates for the mixed boundary-initial-value problem of linear elastodynamics.

85-1979
Bifurcation Analysis of Nonlinear Turning Point Problems
C.G. Lange, G.A. Kriegsmann
Univ. of California, Los Angeles, CA
SIAM J. Appl. Math., 45 (2), pp 175-199
(Apr 1985) 3 figs, 1 table, 17 refs

KEY WORDS: Boundary value problems, Bifurcation theory, Perturbation theory

A bifurcation analysis is carried out on a class of nonlinear two-point boundary value problems for which the associated linearized equations have turning point structure. A perturbation method is used to study the behavior of solutions branching from large eigenvalues.

85-1980
Secondary Bifurcation of Quasi-Periodic Solutions Can Lead to Period Multiplication
J.B. Grotberg, E.L. Reiss
Northwestern Univ., Evanston, IL 60201
SIAM J. Appl. Math., 45 (2), pp 169-174
(Apr 1985), 1 fig, 16 refs

KEY WORDS: Boundary value problems, Bifurcation theory

Perturbation and asymptotic methods are used to obtain the secondary bifurcation of quasi-periodic solutions from periodic solutions for a model problem. It is a two-cell model consisting of a coupled system of van der Pol-Duffing oscillators.

85-1981
Differential Methods in Inverse Scattering
A.M. Bruckstein, B.C. Levy, T. Kailath
Stanford Univ., Stanford, CA 94305
SIAM J. Appl. Math., 45 (2), pp 312-335
(Apr 1985), 4 figs, 51 refs

KEY WORDS: Wave scattering, Differential equations

A new set of differential methods for solving the inverse scattering problem associated with the propagation of waves in an inhomogeneous medium are discussed. By

writing the medium equations in the form of a two-component system describing the interaction of rightward and leftward propagating waves, the causality of the propagation phenomena is exploited in order to identify the medium layer by layer.

85-1982
Finite Element Analysis of Nonlinear Oscillators
K. Krishnamurthy, T.D. Burton, L.D. Zeller
Washington State Univ., Pullman, WA
Intl. J. Numer. Methods Engrg., 21 (3), pp 409-420 (1985), 5 figs, 5 tables, 24 refs

KEY WORDS: Finite element technique, Nonlinear systems, Periodic response

A finite element method for the analysis of nonlinear oscillations which exhibit periodic response is presented. The basic idea of the method is to recast the initial value problem as a boundary value problem in which the domain (period) may be unknown.

85-1983
Maximum Likelihood Estimation of Seismic Impulse Responses
B. Holberg
Selskapet for Industriell og Teknisk Forskning, Norges Tekniske Hoegskole, Trondheim, Norway
Rept. No. STF28-A84003, 36 pp (Feb 1984), PB85-123008

KEY WORDS: Seismic excitation, Maximum likelihood method

A seismic trace is assumed to consist of a known signal pulse convolved with a reflection coefficient series plus a moving average noise process (colored noise). The method of maximum likelihood is used to estimate the reflection coefficients and the unknown noise parameters. If the reflection coefficients are known from well logs, the seismic pulse and the noise parameters can be estimated. When the further assumption is made that the noise is white, the method of maximum likelihood is equivalent to the method of least squares.

KEY WORDS: Lumped parameter method,
Topological methods, Method of structural
numbers

The method of structural numbers (MSN),
which is a relatively new approach to the
analysis of a class of lumped mechanical
vibration systems is presented. In recent
years the MSN has been substantially devel-
oped and, due to rapid progress in the
fields of modification analysis, sensitivity
analysis, synthesis and optimization, new
areas of application of MSN have been
revealed.

KEY WORDS: Pendulums, Equations of
motion, Numerical methods

The bifilar pendulum is often used for indi-
rect measurements of mass moments of
inertia of bodies that possess complex
geometries. The exact equation of motion
of the bifilar pendulum is highly nonlinear,
and has not been solved in terms of ele-
mentary functions. Extensive use has been
made, however, of the linearized approxi-
mation to the exact equation, and it has
been assumed that the simple harmonic
oscillator adequately describes the motion
of the bifilar pendulum. It is shown here
that such is generally not the case. Nu-
merical solutions to the exact nonlinear
differential equations of motion are obtained
for a range of values of initial angular

displacement, filament length, and radius of
gyration.

KEY WORDS: Lanczos method

The simple Lanczos method presented re-
cently, with application to single vector
loads, is extended to include a more gen-
eral dynamic loading represented as a lin-
ear combination of k vectors (load
patterns). The result is a set of orthogonal
vectors that is used to transform the equa-
tions of motion to a banded form.

KEY WORDS: Underground explosions,
Green function

Elastodynamic problems in half-spaces sub-
ject to impulsive buried point loads or other
sources is studied. These problems are
directly related to fundamental singular
solutions (i.e., Green's functions) for the
half-space geometry. This paper is directed
at developing a Green's function for a
two-dimensional, isotropic half-space.

Dynamische Probleme. Modellierung und Wirklichkeit. Proc. of a Meeting, Oct 4-5, 1984, Hannover, Curt-Risch-Institut der Universitat Hannover, Hannover, Fed. Rep. Germany, Vol. I, pp 45-68, 12 figs, 8 refs (In German)

KEY WORDS: Substructuring methods

The dynamic response of a complex structure is approximated from measured and calculated parameters of its substructures. Using measured or calculated modal parameters of the substructures the dynamics of the complete system are approximated. The coupled eigenvalue problem is bypassed. The changes in natural frequency, mode shape, and damping of the main system caused by the addition of supplementary system obtained by the method described are compared with the measurement and FEM results for the entire system. Nonlinear transfer properties of joints in the approximation method are handled on the basis of equivalent linearization.

KEY WORDS: Natural frequencies, Mode shapes

A method is developed for the solution of eigenvalue problems with symmetric matrices and a positive definite frequency constant. A dynamic stiffness matrix whose elements are transcendental functions of the radian natural frequency is allowed. The method enables all natural frequencies and mode shapes across a prescribed frequency range to be determined infallibly and in ascending frequency order at a speed approaching twice that associated with bisection and sing counting methods. It is ideally suited for use on micro- and minicomputers where single precision working is the norm. Much larger problems, of course, may be dealt with on mainframe machines.

MODELING TECHNIQUES

KEY WORDS: Fans, Sound waves, Wave radiation, Finite element technique

The radiation of fan generated noise to the far field from a nacelle of realistic geometry is investigated using the finite element method. Several innovations have been introduced to minimize the computational requirements and create a highly efficient numerical scheme.

KEY WORDS: Mathematical models

For the description and calculation of the dynamic response of a structure under various loads a mathematical model of the system is needed. An identification algorithm is presented which enables to correct the mathematical model from the known natural frequencies in such a way that the difference between the calculated and measured frequencies becomes minimal. This is attained through determination of the

weighting factors for the element matrices. The Sauss-Newton method is used.

NONLINEAR ANALYSIS

KEY WORDS: Component mode synthesis, Computer programs

MSC/NASTRAN was used to compare three techniques of component mode synthesis (CMS) using free modes. A free-free beam model was analyzed by the three methods and compared to the finite element results for the entire beam. The three CMS techniques use different combinations of assumed displacement vectors.

KEY WORDS: Mathematical models

The method of multibody systems, finite element technique, and the method of continuous systems for dynamic modeling of structures are described and illustrated by simple examples.

STATISTICAL METHODS

KEY WORDS: Earthquake simulation, Mathematical models

A smoothness priors-time varying autoregressive (AR) coefficient model method for the modeling of earthquake ground motion is shown. The method yields the instantaneous smoothed values of the AR coefficients and the instantaneous smoothed values of the innovations variance. These results in turn yield estimates of the instantaneous spectral density, the time varying covariance function and a simulation model for the ground motion data.

KEY WORDS: Stochastic processes

Using examples from structural and machine industry the need for a theoretical treatment of stochastic processes in dynamics is illustrated. The classical power spectrum theory with its assumptions is described.

85-1996
**Failure Probability of Dynamic Systems
Caused by Damage Accumulation (Versagen-
swahrscheinlichkeit dynamischer Systeme
bei Schadensakkumulation)**
E. Grossmann, R. Rackwitz
Technische Universitat Munchen, Fed. Rep.
Germany
Dynamische Probleme. Modellierung und
Wirklichkeit. Proc. of a Meeting, Oct 4-5,
1984, Hannover, Curt-Risch-Institut der
Universitat Hannover, Hannover, Fed. Rep.
Germany, Vol. I, pp 281-302, 24 refs (In
German)

KEY WORDS: Statistical analysis, Fracture
properties, Reliability, Crack propagation

A dynamic system under Gaussian excita-
tion, whose components become damaged
over a period (scalar damage), is investi-
gated.

PARAMETER IDENTIFICATION

85-1997
**Experimental Determination of Stiffness
and Inertia Coefficients of Torsional Ele-
ments (Experimentelle Ermittlung der Steif-
igkeits- und Tragheitskoeffizienten von
Torsionselementen)**
R. Nordmann, P. Schibinger, M. Keim
Universitat Kaiserslautern, Fed. Rep. Ger-
many
Dynamische Probleme. Modellierung und
Wirklichkeit. Proc. of a Meeting, Oct 4-5,
1984, Hannover, Curt-Risch-Institut der
Universitat Hannover, Hannover, Fed. Rep.
Germany, Vol. II, pp 455-478, 11 figs, 3
refs (In German)

KEY WORDS: Torsional vibration, System
identification technique

A method of system identification for ex-
perimental determination of stiffness and
inertia parameters of complicated torsional
elements is presented.

85-1998
**The Application of Shifted Legendre Poly-
nomials to Time-Delay Systems and Pa-
rameter Identification**
Rong-Yeu Chang, Maw-Ling Wang
National Tsing Hua Univ., Hsinchu, Taiwan,
Rep. of China
J. Dynam. Syst., Meas. Control, Trans.
ASME, 107 (1), pp 79-85 (Mar 1985) 1 fig,
1 table, 18 refs

KEY WORDS: Parameter identification tech-
nique, Time-delay systems

A linear time-delay state equation is solved
by the proposed shifted Legendre polynomi-
als method. The parameter identification
of such a system with time delay is also
studied.

85-1999
**The Identification of Mechanical Systems
(Zur Identifikation mechanischer Systeme)**
H.G. Natke
Curt-Risch-Institut f. Dynamik, Schall- und
Messtechnik, Universität Hannover,
Callinstr. 32, 3000 Hannover 1, Fed. Rep.
Germany
Dynamische Probleme. Modellierung und
Wirklichkeit. Proc. of a Meeting, Oct 4-5,
1984, Hannover, Curt-Risch-Institut der
Universität Hannover, Hannover, Fed. Rep.
Germany, Vol. II, pp 417-440, 1 fig, 31
refs (In German)

KEY WORDS: System identification

In the dynamically complicated linear elas-
tomechanical system the mathematical
model belongs to a priori knowledge. Meth-
ods for linear systems are discussed using
their mathematical models. The identifica-
tion method is based on the excitation and
response measurement and on measured
natural frequencies.

COMPUTER PROGRAMS

85-2000
**Vibration Analysis of Frame and Cable-
Stayed Footbridges by 'VAFCAF'**

J.T. Cheung
Transport and Road Research Lab., Crow-
thorne, England
Rept. No. TRRL/SR-824, 36 pp (1984)
PB85-116788/GAR

KEY WORDS: Computer programs, Vibration
analysis, Finite element technique, Cable
stayed structures, Frames

The computer program VAFCAF has been
developed; it is based on the finite element
method and is intended for use in analyzing
the behavior of cable-stayed footbridges,
continuous beams and plane frames. The
Timoshenko beam element has been incor-
porated into the program.

85-2001
Finite Element Analysis on Your PC
K. Blakely, B. Lahey, D. McLean
MacNeal-Schwendler Corp., Los Angeles, CA
S/V, Sound Vib., 19 (1), pp 26-32 (Jan
1985) 20 figs, 3 tables, 2 refs

KEY WORDS: Computer programs, Finite
element technique

An overview of MSC/pal, a PC program
for three-dimensional static and dynamic
finite element analysis is presented. Sev-
eral examples show that meaningful stress
and vibration analyses can be performed
with a personal computer, benefiting struc-
tural analysts, designers, and testers.

85-2002
The Dynamic Duo: Dram and Adams
G. Dawson
Mechanical Dynamics, Inc., Ann Arbor, MI
Computers Mech. Engrg., 3 (5), pp 20-24
(Mar 1985) 5 figs

KEY WORDS: Machines, Design techniques,
Computer programs

The first general-purpose program to calcu-
late the time response of multifreedom,
constrained machinery undergoing large
displacements -- DRAM (Dynamic Response
of Articulated Machinery) -- is described. A
second program ADAMS (Automated Dy-
namic Analysis of Mechanical Systems),
designed as a three-dimensional, large-dis-
placement dynamics program that could also
handle kinematics and statics problems, is
also described.

AUTHOR INDEX

ABSTRACT CATEGORIES

MECHANICAL SYSTEMS

Rotating Machines
Reciprocating Machines
Power Transmission Systems
Metal Working and Forming
Isolation and Absorption
Electromechanical Systems
Optical Systems
Materials Handling
  Equipment

STRUCTURAL SYSTEMS

Bridges
Buildings
Towers
Foundations
Underground Structures
Harbors and Dams
Roads and Tracks
Construction Equipment
Pressure Vessels
Power Plants
Off-shore Structures

VEHICLE SYSTEMS

Ground Vehicles
Ships
Aircraft
Missiles and Spacecraft

BIOLOGICAL SYSTEMS

Human
Animal

MECHANICAL COMPONENTS

Absorbers and Isolators
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Tires and Wheels

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Bearings
Belts
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Seals
Cams

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Strings and Ropes
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Bars and Rods
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Controls (Switches,
  Circuit Breakers
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DYNAMIC ENVIRONMENT

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Damping
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Elasticity and Plasticity
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Scaling and Modeling
Diagnostics
Balancing
Monitoring

ANALYSIS AND DESIGN

Analogs and Analog
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Nonlinear Analysis
Numerical Methods
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Mobility/Impedance Methods
Optimization Techniques
Design Techniques
Computer Programs

GENERAL TOPICS

Conference Proceedings
Tutorials and Reviews
Criteria, Standards, and
  Specifications
Bibliographies
Useful Applications

CALENDAR

1985

OCTOBER

2-4 International Acoustics Symposium, Pretoria, South Africa (Symposium Secretariat IRS, CSIR, P.O. Box 395, Pretoria 0001, South Africa)

6-8 Diesel and Gas Engine Power Technical Conference [ASME] West Middlesex, PA (ASME)

8-10 Lubrication Conference [ASLE/-ASME] Atlanta, GA (ASLE/ASME)

8-11 Stapp Car Crash Conference [SAE] Arlington, VA (SAE)

14-17 Aerospace Congress and Exposition [SAE] Los Angeles, CA (SAE)

20-24 Power Generation Conference [ASME] Milwaukee, WI (ASME)

22-24 14th Turbomachinery Symposium [Turbomachinery Labs.] Houston, TX (Dara Childs, Turbomachinery Labs., Dept. of Mech. Engrg., Texas A&M Univ., College Station, TX 77843)

22-24 56th Shock and Vibration Symposium [Shock and Vibration Information Ctr., Washington, D.C.] Monterey, CA (Dr. J. Gordan Showalter, Acting Director, SVIC, Naval Res. Lab., Code 5804, Washington, D.C. 20375-5000 - (202) 767-2220)

NOVEMBER

4-8 Acoustical Society of America, Fall Meeting [ASA] Nashville, TN (ASA)

11-14 Truck and Bus Meeting and Exposition [SAE] South Bend, IN (SAE)

17-22 American Society of Mechanical Engineers, Winter Annual Meeting [ASME] Miami Beach, FL (ASME)

24-26 Australian Acoustical Society Annual Conference, Leura, Australia (A. Lawrence, Graduate School, University of N.S.W., Box 1, Kensington, N.S.W. 2033, Australia)

DECEMBER

11-13 Western Design Engineering Show [ASME] Anaheim, CA (ASME)

1986

JANUARY

28-30 Reliability and Maintainability Symposium [ASME] Las Vegas, NV (ASME)

MARCH

5-7 Vibration Damping Workshop II [Flight Dynamics Laboratory of the Air Force Wright Aeronautical Labs.] Las Vegas, NV (Mrs. Melissa Arrajj, Administrative Chairman, Martin Marietta Denver Aerospace, P.O. Box 179, Mail Stop M0486, Denver, CO 80201 - (303) 977-8721)

24-27 Design Engineering Conference and Show [ASME] Chicago, IL (ASME)

APRIL

8-11 International Conference on Acoustics, Speech, and Signal Processing [Acoustical Society of Japan, IEEE ASSP Society, and Institute of Electronics and Communication Engineers of Japan] Tokyo, Japan (Hiroya Fujisaki, EE Department, Faculty of Engineering, University of Tokyo, Bunkyo-ku, Tokyo 113, Japan)

13-16 American Power Conference [ASME] Chicago, IL (ASME)

29-1 9th International Symposium on Ballistics [Royal Armament Research and Development Establishment] RMCS, Shrivenham, Wiltshire, UK (Mr. N. Griffiths, OBE, Head/XT Group, RARDE, Fort Halstead, Sevenoaks, Kent TN14 7BP, England)

MAY

12-16 Acoustical Society of America, Spring Meeting [ASA] Cleveland, OH (ASA Hqs.)

JUNE

3-6 Symposium and Exhibit on Noise Control [Hungarian Optical, Acoustical, and Cinematographic Society; National Environmental Protection Authority of Hungary] Szeged, Hungary (Mrs. Ildiko Baba, OPAKFI, Anker koz 1, 1061 Budapest, Hungary)

4-6 Machinery Vibration Monitoring and Analysis Meeting [Vibration Institute] Las Vegas, NV (Dr. Ronald L. Eshleman, Director, The Vibration Institute, 101 W. 55th St., Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254)

JULY

20-24 International Computers in Engineering Conference and Exhibition [ASME] Chicago, IL (ASME)

21-23 INTER-NOISE 86 [Institute of Noise Control Engineering] Cambridge, MA (Professor Richard H. Lyon, Chairman, INTER-NOISE 86, INTER-NOISE 86 Secretariat, MIT Special Events Office, Room 7-111, Cambridge, MA 02139)

24-31 12th International Congress on Acoustics, Toronto, Canada (12th ICA Secretariat, P.O. Box 123, Station Q, Toronto, Ontario, Canada M4T 2L7)

SEPTEMBER

14-17 International Conference on Rotordynamics [IFToMM and Japan Society of Mechanical Engineers] Tokyo, Japan (Japan Society of Mechanical Engineers, Sanshin Hokusei Bldg., 4-9, Yoyogi 2-chome, Shibuyak-ku, Tokyo, Japan)

22-25 World Congress on Computational Mechanics [International Association of Computational Mechanics] Austin, Texas (WCCM/TICOM, The University of Texas at Austin, Austin, TX 78712)

OCTOBER

5-8 Design Automation Conference [ASME] Columbus, OH (ASME)

5-8 Mechanisms Conference [ASME] Columbus, OH (ASME)

19-23 Power Generation Conference [ASME] Portland, OR (ASME)

20-22 Lubrication Conference [ASME] Pittsburgh, PA (ASME)

NOVEMBER

30-5 American Society of Mechanical Engineers, Winter Annual Meeting [ASME] San Francisco, CA (ASME)

CALENDAR ACRONYM DEFINITIONS
AND ADDRESSES OF SOCIETY HEADQUARTERS

AHS American Helicopter Society
1325 18 St. N.W.
Washington, D.C. 20036

AIAA American Institute of Aeronautics
and Astronautics
1633 Broadway
New York, NY 10019

ASA Acoustical Society of America
335 E. 45th St.
New York, NY 10017

ASCE American Society of Civil Engineers
United Engineering Center
345 E. 47th St.
New York, NY 10017

ASLE American Society of Lubrication
Engineers
838 Busse Highway
Park Ridge, IL 60068

ASME American Society of Mechanical
Engineers
United Engineering Center
345 E. 47th St.
New York, NY 10017

ASTM American Society for Testing and
Materials
1916 Race St.
Philadelphia, PA 19103

ICF International Congress on Fracture
Tohoku University
Sendai, Japan

IEEE Institute of Electrical and Electronics Engineers
United Engineering Center
345 E. 47th St.
New York, NY 10017

IES Institute of Environmental Sciences
940 E. Northwest Highway
Mt. Prospect, IL 60056

IMechE Institution of Mechanical Engineers
1 Birdcage Walk, Westminster
London SW1, UK

IFToMM International Federation for Theory of Machines and Mechanisms
U.S. Council for TMM
c/o Univ. Mass., Dept. ME
Amherst, MA 01002

INCE Institute of Noise Control Engineering
P.O. Box 3206, Arlington Branch
Poughkeepsie, NY 12603

ISA Instrument Society of America
67 Alexander Dr.
Research Triangle Pk., NC 27709

SAE Society of Automotive Engineers
400 Commonwealth Dr.
Warrendale, PA 15096

SEE Society of Environmental Engineers
Owles Hall, Buntingford, Hertz.
SG9 9PL, England

SESA Society for Experimental Mechanics (formerly Society for Experimental Stress Analysis)
14 Fairfield Dr.
Brookfield Center, CT 06805

SNAME Society of Naval Architects and
Marine Engineers
74 Trinity Pl.
New York, NY 10006

SPE Society of Petroleum Engineers
6200 N. Central Expressway
Dallas, TX 75206

SVIC Shock and Vibration Information
Center
Naval Research Laboratory
Code 5804
Washington, D.C. 20375-5000

PUBLICATION POLICY

Unsolicited articles are accepted for publication in the **Shock and Vibration Digest**. Feature articles should be tutorials and/or reviews of areas of interest to shock and vibration engineers. Literature review articles should provide a subjective critique/summary of papers, patents, proceedings, and reports of a pertinent topic in the shock and vibration field. A literature review should stress important recent technology. Only pertinent literature should be cited. Illustrations are encouraged. Detailed mathematical derivations are discouraged; rather, simple formulas representing results should be used. When complex formulas cannot be avoided, a functional form should be used so that readers will understand the interaction between parameters and variables.

Manuscripts must be typed (double-spaced) and figures attached. It is strongly recommended that line figures be rendered in ink or heavy pencil and neatly labeled. Photographs must be unscreened glossy black and white prints. The format for references shown in Digest articles is to be followed.

Manuscripts must begin with a brief abstract, or summary. Only material referred to in the text should be included in the list of References at the end of the article. References should be cited in text by consecutive numbers in brackets, as in the following example:

> Unfortunately, such information is often unreliable, particularly statistical data pertinent to a reliability assessment, as has been previously noted [1].

> Critical and certain related excitations were first applied to the problem of assessing system reliability almost a decade ago [2]. Since then, the variations that have been developed and practical applications that have been explored [3-7] indicate . . .

The format and style for the list of References at the end of the article are as follows:

-- each citation number as it appears in text (not in alphabetical order)
-- last name of author/editor followed by initials or first name
-- titles of articles within quotations, titles of books underlined
-- abbreviated title of journal in which article was published (see Periodicals Scanned list in January, June, and December issues)
-- volume, issue number, and pages for journals; publisher for books
-- year of publication in parentheses

A sample reference list is given below.

1. Platzer, M.F., "Transonic Blade Flutter -- A Survey," Shock Vib. Dig., 7 (7), pp 97-106 (July 1975).

2. Bisplinghoff, R.L., Ashley, H., and Halfman, R.L., Aeroelasticity, Addison-Wesley (1955).

3. Jones, W.P., (Ed.), "Manual on Aeroelasticity," Part II, Aerodynamic Aspects, Advisory Group Aeronaut. Res. Dev. (1962).

Articles for the Digest will be reviewed for technical content and edited for style and format. Before an article is submitted, the topic area should be cleared with the editors of the Digest. Literature review topics are assigned on a first come basis. Topics should be narrow and well-defined. Articles should be 3000 to 4000 words in length. For additional information on topics and editorial policies, please contact:

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THE SHOCK AND VIBRATION DIGEST

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